3.2 MARINE WATER QUALITY AND SEDIMENT QUALITY

Section 3.2 describes the existing marine water quality and sediment quality conditions at the 4H shell mound sites, identifies significance criteria, assesses potential impacts of each Program Alternative, and recommends measures to mitigate significant adverse impacts. The Environmental Setting includes a discussion of oceanographic and geologic conditions. While oceanographic conditions will not be affected by the Program Alternatives, currents will affect the dispersion and dilution of shell mound materials during removal, as well as the possible long-term fate of the shell mounds if they are left in place or covered with a cap or reef. Therefore, oceanographic processes remain important considerations for assessing potential impacts to marine resources. Similarly, marine geology will not be affected, but it is part of the background for sediment quality.

3.2.1 Environmental Setting

3.2.1.1 Oceanography

Regional Oceanographic Conditions

Oceanographic conditions in the Santa Barbara Channel (Channel) portion of the Southern California Bight (SCB) are described by the Minerals Management Service (MMS 2001), which is the basis for the following summary. The three primary sources of ocean waters to the SCB are: (1) sub-arctic water transported south by the California Current and California Countercurrent; (2) Central North Pacific water moving from the west into the SCB; and (3) equatorial waters entering the SCB from the south, especially via the California Undercurrent. Distributions of these water masses account for the low salinity and high dissolved oxygen (DO) content of waters within the surface 660 feet (ft) or 200 meters (m), which are characteristic of the sub-arctic water mass, and the high salinity and low DO concentrations of underlying waters, typical of equatorial Pacific water masses.

Currents along the western coast of the United States are dominated by the southward-flowing California Current, which is the eastern expression of the ocean-wide subtropical anticyclonic gyre in the Pacific Ocean. The California Current is a broad, slow-moving current with considerable regional-scale variability that brings cold, low-salinity, highly oxygenated water from the north. South of Point Conception, the California Current mixes with the warmer, moderately saline, Central North Pacific water. South of San Diego, a portion of the California Current turns counter-clockwise (towards shore), eventually forming the poleward-flowing California Countercurrent. The Countercurrent typically is 6.2 to 12 miles (10 to 20 kilometers [km][1]) wide with velocities less than 1 foot per second (ft/s) or 30 centimeters/second (cm/s), but it is broader and stronger in the winter when it occasionally covers the continental shelf and is referred to

1 To the extent possible, English units with corresponding metric unit equivalents are used in this section. Because standard conventions for concentration units are based on metric weights, metric concentration units are used without the English unit equivalents.

as the Davidson Current. The California Undercurrent also flows poleward, typically within 62 miles (100 km) of the coast at depths below 660 ft (200 m), transporting warm, highly saline, low DO waters into the SCB.

The seasonal surface circulation in the SCB is complex and highly variable. The topography of the basins and ridges and coastal indentations strongly influences surface and bottom circulation and tends to control the formation and dissipation of eddies and meanders. Sills of the ridges control the exchange of water between the basins and, hence, affect not only the water properties of the basins, but also the exchange and distribution of sediments, and biological and anthropogenic (originating from humans) inputs.

Currents in the Channel are influenced by large-scale processes that dominate the physical oceanographic conditions along the California Coast, although the effects are somewhat limited by the presence of the Channel Islands and basin-ridge topography of the Channel. Large-scale equatorward flow occurs in spring in response to strong winds, accompanied by decreases in surface temperature. Late spring/summer currents reverse due to strengthening of alongshelf pressure gradients. Poleward flow is sustained through fall and early winter, accompanied by increasing water temperatures. The alongshelf flow over the northern Channel shelf typically is westerly, whereas currents over the southern Channel shelf typically are easterly, establishing a counter-clockwise flow pattern in the Channel. The intensity of the counter-clockwise flow intensifies and reaches a maximum in summer and early fall, then weakens throughout winter to early spring. A smaller-scale complex circulation may result from the convergence of the two eddies in the central channel area between Santa Cruz Island and Santa Barbara (Lagerloef 1991; Kolpack 1971; Pirie et al. 1975).

Regional oceanographic conditions also vary with El Niño events, which occur irregularly but usually once or twice in a decade. El Niño events are associated with warm waters that are transported northward, and they have resulted in heavy and prolonged precipitation and high river runoff that spreads sediment plumes from the Ventura/Santa Clara Rivers past Point Conception and to the vicinity of San Miguel Island (MMS 2001).

WAVES

The wave climate for the Channel is affected by the complex topography of the basins and ridges and the presence of the offshore islands, which tend to dissipate the wave energy further offshore. Coastal areas within the Channel are more protected from wind and waves by the offshore features. The Channel is susceptible to wave fronts from the west-southwest, southeast, and the passages of the Channel Islands (wave windows). However, the east and west ends of the Channel are affected differently because of the protection provided by Point Conception, the length of the Channel (fetch), and the orientation of the Channel Island passages with respect to the mainland.

Local storms from the southeast generate wind waves (seas) over a fetch of 90 miles (145 km). These seas have significant wave heights that range from 7.9 to 16 ft

(2.4-4.8 m) and generally have short periods (8-9 s). Swells enter the Channel from the west-southwest, between San Miguel Island and Point Conception, and the Channel Island wave window. These swells have significant wave heights and periods that range from 1 tp 16 ft (0.3-5.0 m) and 8 to 16 s, with averages of 3 ft (0.9 m) and 12 s, respectively (Gable 1981); the highest waves were swells with periods of 14 to 16 s and occurred in April (hindcast study by National Marine Consultants 1960). The predominant directions of the swells were west-northwest, west, west-southwest, and southeast, with southeast swells generally having shorter periods. Wind waves had significant wave heights generally lower than swells and had a maximum period of 12 s. The highest wind waves were from the southeast.

TIDES

Tides in the Santa Barbara area are mixed, semidiurnal (two times per day) with a range of 5 to 6 ft (1.5-2 m). The tide enters the Channel via the southeast end, moves northward up the coast, and exits at the west end (Emery 1960; Hendershott 1981). The difference in time of peak tide between the east and west ends is typically one hour with the tide proceeding northward up the coast. Average tidal-induced currents are approximately 0.3 ft/s (10 cm/s). However, constrictions between islands (passes) and regions near promontories and peninsulas (e.g., Point Conception) can be expected to accelerate tidal currents.

HYDROGRAPHIC CONDITIONS

Hydrographic conditions (temperature, salinity, stratification) in the Channel are subject to the influence of larger-scale oceanographic and seasonal patterns, precipitation, and runoff. The temperature gradient varies seasonally in response to variations in upwelling-favorable winds and the alongshelf pressure gradient. In spring, upwelled cold water may be transported eastward into the Channel. Subsequent warming associated with the reversal of flows allows greater penetration into the Channel by the warmer SCB waters. Typical average water temperatures range from about 56.3^{o}F (13.5°C) during late winter to 64.4^{o}F (18°C) in summer/fall. Temperatures typically decrease with increasing water depth to about 42.8^{o}F (6°C) in the deep central basins, where seasonal variations are minimal compared with those in the surface layers. Surface water salinity also exhibits a seasonal pattern, with maximum values in summer and minimum values in winter. Surface salinity values range from 32.5 to 33.5 parts per thousand (ppt). Salinity values associated with deep basin waters are about 34.5 ppt with minimal seasonal change.

During summer and fall, SCB waters typically are stratified, with rapid changes in temperature and density (thermocline/pycnocline) separating the warmer, surface mixed layer from the cooler, subsurface layers. The presence of strong stratification can act as a barrier to vertical dispersion of substances in the water column. Stratification weakens under the influence of upwelling events, seasonal cooling cycles, and storm-induced turbulence. Two important factors that contribute to vertical stratification of Channel waters are (1) decreases in temperature with depth, and (2) increases in salinity with depth. Stability is directly proportional to stratification, is at a minimum during winter,

and reaches peak values during spring and summer (Allan Hancock Foundation 1965). The high values in spring and summer and the low values in winter are the result of the seasonal development and erosion of the thermocline, a seasonal cycle that affects the amount of vertical mixing and dispersion of particles.

Local Conditions (in Vicinity of 4H Shell Mound Sites)

Currents at depths of 85 ft (26 m) and 105 ft (32 m) (23 ft or 7 m above the bottom) in the vicinity of the 4H shell mounds (shallow and deep shell mounds, respectively) were measured in conjunction with the February through April, 2003, caged mussel bioassay study (SAIC 2003; Appendix G). Average and maximum current speeds were 0.2 and 0.9 ft/s (6.8 and 29 cm/s), respectively, at the shallow site and 0.3 and 1.1 ft/s (9.8 and 34 cm/s), respectively, at the deep site. The predominant current directions at both sites were westerly (261 to 281 degrees) and parallel to the local bottom contours. Bascom et al. (1976) reported an average current speed of 0.3 ft/s (8 cm/s), with maximum speeds of 0.7 ft/s (21 cm/s), at a depth 23 ft (7 m) above the bottom close to Platform Hilda. Predominant currents measured by Bascom et al. flowed parallel to the bottom isobaths, although current directions reversed during the tidal cycle. Currents measured near the Goleta Sanitary District's ocean outfall, approximately 15 miles (24 km) west of the 4H shell mounds, were predominantly westerly with maximum current speeds of 0.5 ft/s (17 cm/s) at depths of 20 ft (6 m) and 62 ft (19 m), although current speeds were 0.3 ft/s (8 cm/s) or less at least 50 percent of the time (Brown and Caldwell 1997, cited in de Wit 2001). Harms and Winant (1998) measured current speeds and directions at the Carpinteria Inshore (CAIN) mooring (approximately 9 to 14 miles [15 to 22 km] from the 4H shell mounds at 34˚ 13´ 52˝; 119˚ 34´ 34˝; 330 ft [100 m] bottom depth; see Figure 3.2-1): the average current speed at a depth of 16 ft (5 m) was 0.2 ft/s (7.2 cm/s), flowing in a northwesterly direction (305 degrees); at 150 ft (45 m), the average speed was 0.5 ft/s (14.7 cm/s), flowing in the same direction as surface currents.

Conditions at LA-2 Ocean Dredged Material Disposal Site

Oceanographic and hydrographic conditions at the LA-2 ocean dredged material disposal site (LA-2) are described by USEPA (1988). Currents in the area of LA-2 primarily move parallel to the bottom contours, with only weak onshore and offshore movement. Consequently, sediment transport at the site is expected to be along the isobaths and/or downslope towards San Pedro Basin.

3.2.1.2 Marine Water Quality

Regional and Local Conditions

DISSOLVED OXYGEN (DO)

Variations in DO concentrations in the Channel reflect natural mixing and biological processes. DO concentrations in surface waters typically range from 6 - 9 milligrams per liter (mg/L) and are at or exceed saturation. Maximum DO concentrations occur in June and July, whereas relatively lower levels occur during periods of spring upwelling. Oxygen levels decrease with depth, and reach minimal levels within the offshore basins.

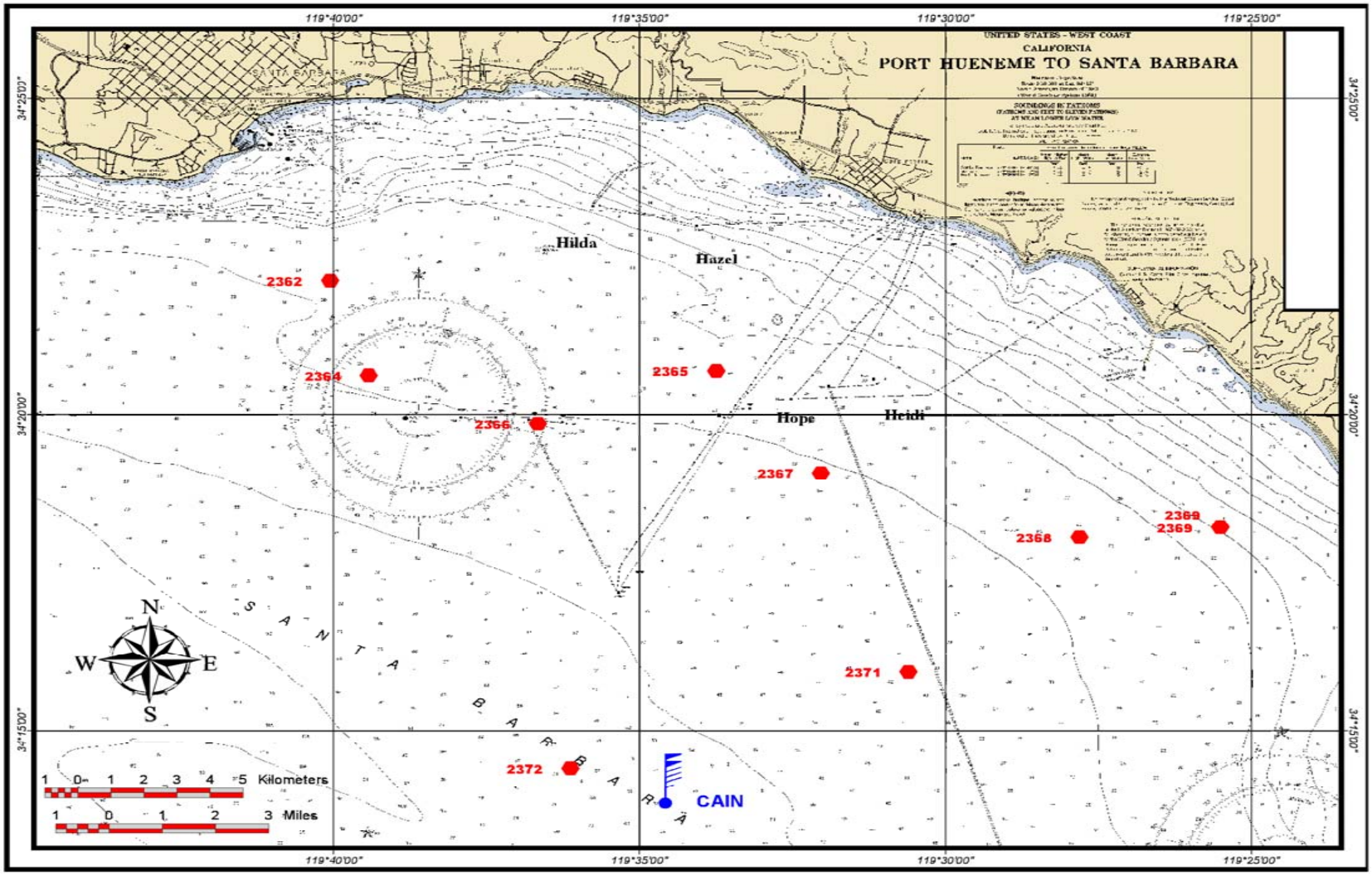


Figure 3.2-1. Locations of the Bight '98 Sediment Sampling Stations and the Physical Oceanographic Mooring CAIN in the Santa Barbara Channel

pH

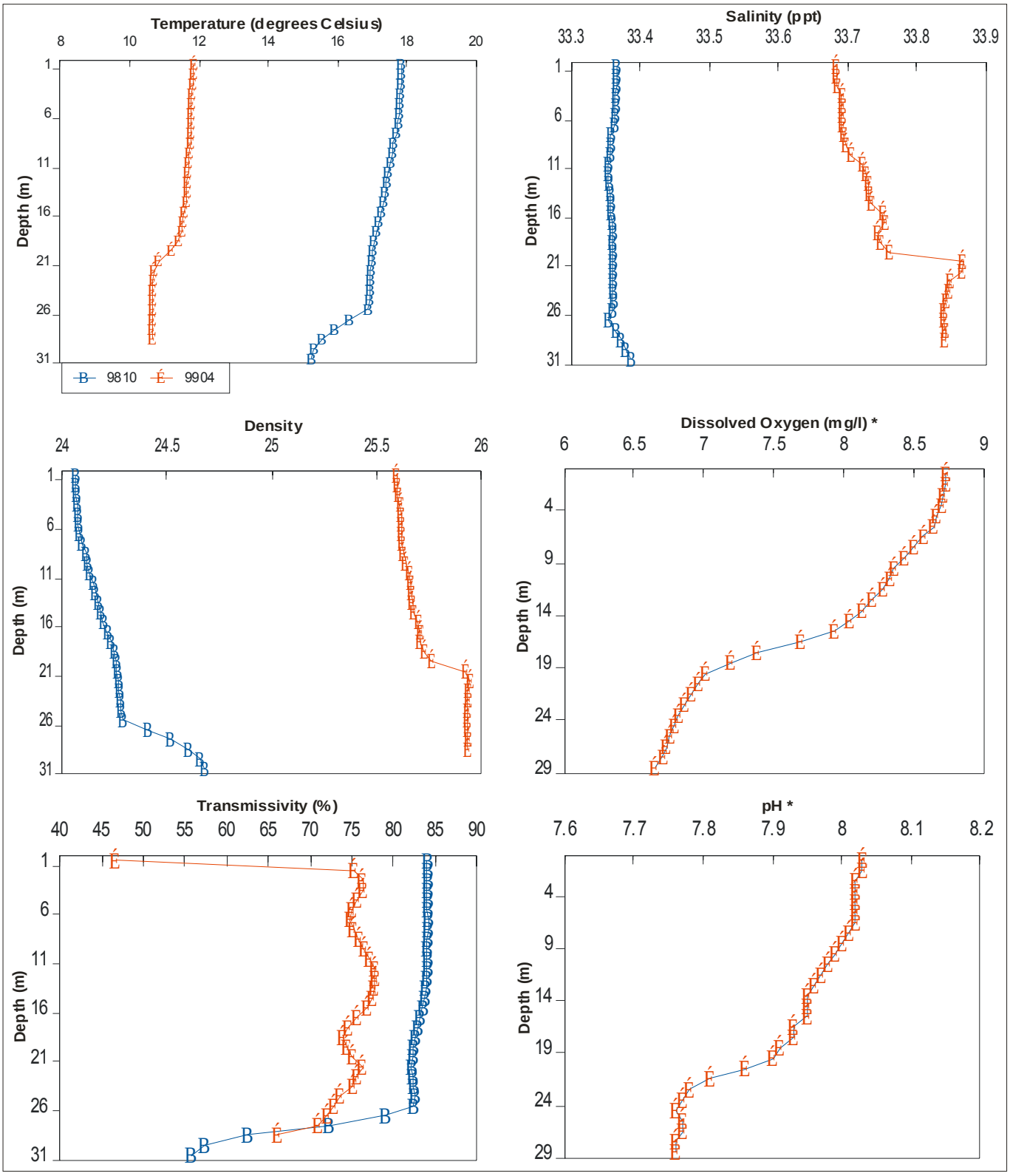
Hydrogen ion concentrations (pH) are expected to range from 7.8 to 8.1. Because seawater is a highly buffered medium, pH levels in seawater are relatively uniform, and neither large horizontal nor vertical variations nor seasonal trends are expected.

Light Transmittance/Turbidity

The relative amount of light transmitted through surface waters determines the depth of the euphotic or lighted zone in which photosynthesis by phytoplankton and attached algae occurs. Variations in the concentrations of suspended particulate matter, especially suspended sediments and plankton, greatly influence seasonal cycles in light transmittance in Channel waters. In general, greater turbidity accompanies higher suspended loads in nearshore waters, whereas there is increased light transmittance, along with lower suspended particulate concentrations, in offshore waters.

The major sources of suspended particles are river and stream sediments discharged into Channel waters (see Section 3.2.1.3) and phytoplankton. The latter is present in Channel waters at concentrations that vary seasonally with respect to surface water nutrient supplies. Similarly, the contribution of resuspended sediments to water column particulate concentrations may vary with respect to seasonal storm events and different hydrographic regimes associated with bottom turbulence. For example, storm runoff transports large amounts of sediment into coastal waters of the Channel, creating turbidity plumes that cover hundreds of square kilometers and extend offshore to the Channel Islands. Drake (1971) and Drake et al. (1971) described suspended particulate loads and light transmittance values in Channel waters following a large storm event. Values of 70 percent light transmittance per meter (ltpm) were recorded in nearshore surface waters, while 80 percent ltpm occurred in offshore waters. At depths of 160 ft (50 m), lower values of 50 to 70 percent ltpm corresponded to particulate loads of about 10 mg/L. In addition, near-bottom turbidity layers (60 percent ltpm) due south of Point Conception, indicated longshore transport of river-derived sediment around the point.

Water quality conditions (temperature, salinity, DO, pH, transmissivity) in the eastern portion of the Channel were evaluated during October, 1998, and January, March, and April, 1999, as reported in the BIGHT ’98 regional monitoring program. Representative profiles of water quality parameters at a site approximately 6.2 to 9.3 miles (10 to 15 km) from the 4H shell mounds are shown in Figure 3.2-2. Bascom et al. (1976) measured salinity and DO concentrations in waters near Platform Hilda, and reported that values were typical and no anomalies were observed. During the February through April, 2003, caged mussel study at the 4H shell mounds, bottom water temperatures ranged from 48.2^{o} to 59^{o}F (9^{o} to 15^{o}C). Following the passage of winter storms through the region, water temperatures decreased rapidly by 3.6^{o}F (2^{o}C), possibly in response to regional upwelling events (SAIC 2003).



1 * Dissolved oxygen and pH data not available for Survey 9810

2 **Figure 3.2-2. Water Quality Parameters for the Santa Barbara Channel During**
3 **October 1998 (9810) and April 1999 (9904), Data for Bight '98 Station on 146006**

CONTAMINANT SOURCES

Regional sources of chemical and bacterial contaminants include municipal wastewater discharges, natural oil seeps, discharges from offshore oil and gas production platforms, stormwater and river runoff, and discharges from commercial and recreational vessels. Discharges from sewage treatment plants, offshore oil platforms, industrial facilities, and power plants are regulated under State and federal individual and general NPDES permits.

The Goleta Municipal sewage outfall discharges approximately 5 million gallons (19 million liters) per day (mgd) of advanced primary treated wastewaters to the ocean near Goleta Point. The Santa Barbara (El Estero), Montecito, and Carpinteria wastewater facilities, combined, discharge approximately 9 mgd of secondary treated wastewaters, and Summerland discharges 0.2 mgd of tertiary treated wastewaters to the ocean near Santa Barbara. In 2000, these combined discharges accounted for inputs of 430 tons (390 metric tons) of suspended solids, 134 tons (122 metric tons) of oil and grease, 500 pounds (225 kilograms [kg]) of copper, and 1,700 pounds (775 kg) of zinc (SCCWRP 2003).

Natural oil seeps release an estimated 40 to 670 barrels (6,359 to 106,521 liters [1,680 to 28,140 gallons]) of oil per day to the Santa Barbara Channel. The three major seep areas in the Channel are: (1) Point Conception; (2) Coal Oil Point; and (3) Santa Barbara/Rincon, including the area off Carpinteria near the 4H shell mounds. Because of the presence of seeps, waters and sediments of the Santa Barbara Channel have high but spatially and temporally variable background hydrocarbon concentrations. Marine waters above seeps may contain concentrations of saturated and aromatic hydrocarbons that are 2.5 to 18 times and 1 to 4 times higher, respectively, than areas removed from seeps (Reed and Kaplan 1977). Stuermer et al. (1980) reported dissolved hydrocarbon concentrations of 1 to 6 micrograms per liter (µg/L or parts-per-billion) in waters above the Coal Oil Point seep compared to concentrations of 0.2 to 1 µg/L in a reference area. Relatively higher hydrocarbon concentrations (45 to 100 µg/L) occur in sediment pore waters near active seeps.

Conditions at LA-2 Ocean Dredged Material Disposal Site

Background water quality conditions at LA-2 are summarized by USEPA (1988). Water quality at LA-2 varies seasonally in response to oceanographic conditions and effects from coastal runoff following rainfall events. Results from previous surveys did not indicate that dredged material disposal activities resulted in appreciably elevated concentrations of metals or hydrocarbons in site waters (USEPA 1988).

3.2.1.3 Marine Geology and Sediment Quality

Regional Conditions

Regional marine geologic conditions are summarized by CSLC (1994) and MMS (2001). The Channel, which is bounded on the north by the Santa Ynez Range and on the south by the Channel Islands, lies in the western part of the larger Santa Barbara-

Ventura Basin. This Basin is one of several east-west trending tectonic basins formed by differential uplift and subsidence along the axis of the San Andreas Fault system during the last 20 to 35 million years (MMS 2001). Subsequent marine nearshore deposition in a quiet-water environment formed the sequence of sedimentary rocks that characterizes the present-day shoreline and continental shelf (MMS 2001). The region is seismically active as several major earthquakes in the past 100-150 years have been traced to faults that extend into the Santa Barbara-Ventura Basin. High rates of uplift along the coastline are juxtaposed with continuing subsidence of the basins. The nearshore environment of the SCB is characterized by relatively high rates of sedimentation, resulting in a veneer of mixed marine and terrigenous (derived from the mechanical weathering of rocks on land) sediments that covers the underlying sedimentary rocks in most locations, including the shell mounds sites.

In the SCB, the bulk of sediments supplied to the Santa Barbara, Santa Monica, and San Pedro Basins and San Diego Trough is terrigenous in origin and is derived from major rivers along the coast, each of which may have different sediment characteristics. Some of these include the Santa Ynez, Santa Maria, Ventura, and Santa Clara Rivers, which drain into the Channel, and the Santa Ana, San Gabriel, and Los Angeles Rivers, which drain onto the San Pedro Shelf. Small, intermittent streams also discharge periodically into the northern portions of the Santa Barbara coastline. Other sediment sources include dusts from winds, shoreline erosion, longshore and eddy transport (upcoast sources), and biological production (shells, tests, fecal pellets). Sediment input from offshore islands is minor.

Sediment grain size distribution in the Channel is complex due to a variety of sediment sources, variable submarine topography, and a complex circulatory pattern. On the Mainland Shelf province between Santa Barbara and Point Conception, sediments grade from medium to fine sands to silty sands to silts. Sediments of the outer shelf tend to coarsen with sporadic outcrops of bedrock. Sediments of the Smooth Slope province are predominantly silts, which become finer with increasing water depth. Sediments on the Conception Fan province become finer with increasing depth, grading from fine sands and silts to clayey silts and silty clays. Surficial sediments in the submarine canyons, which incise the Fan, are generally finer than the surrounding sediments.

On the Oxnard Shelf, sediments tend to reflect input from the Santa Clara River. The sediment distribution seems to be controlled by the complex water circulation in the area. Drake et al. (1972) examined sediment movement on the Oxnard Shelf following the floods of 1969. They found that fine-grained sediments (silts and clays) moved in the offshore direction with time, indicating current and wave conditions were sufficient to resuspend and transport those sizes towards the shelf break. The finest material eventually was transported to the central basin. From the inner shelf seaward, the sediment graded from well-sorted sands to poorly sorted silts and clays.

Several studies have evaluated sediment transport rates along the Santa Barbara County coastline (Trask 1952, 1955; Bowen and Inman 1966; Judge 1970). The general conclusions from these studies are that a net easterly transport of sediment dominates

east of Pt. Conception, and the annual volume of sediment transported to Santa Barbara is around 280,000 cubic yards (cy) (214,000 cubic meters). The distribution of sediments in the littoral zone and inner shelf is dependent on sediment supply and transporting agents in the area. Wave energy is generally considered the dominant transport agent to depths of 30 to 100 ft (10-30 m). Generally, sediments become finer in the offshore direction. At depths less than 100 ft (30 m), clay-size particles comprise less than 5 percent of the sediments between Goleta and Santa Barbara, whereas sand makes up 60-80 percent of the sediments in depths less than 130 ft (40 m). At depths greater than about 130 ft, the percentages of silt and clay increase.

Conditions in Vicinity of Shell Mounds

BIGHT REGIONAL MONITORING PROGRAM (1998)

Sediment quality data for sites near the 4H shell mounds, sampled during the Bight '98 regional monitoring program, are listed in Table 3.2-1. Metals occur naturally in marine sediments, and bulk concentrations in uncontaminated sediments typically vary in relation to grain size characteristics (i.e., relatively higher concentrations are associated with finer-grained sediments). Polycyclic aromatic hydrocarbons (PAHs) are derived from both natural (e.g., oil seeps) and human sources. In contrast, DDT, PCBs, and chlordane are human-made compounds that do not occur naturally in marine sediments. The presence of low concentrations of these chlorinated compounds, along with generally low concentrations of PAHs and background levels of individual metals, indicate low-level contamination of sediments in the region of the 4H shell mounds.

ONSITE STUDIES (2001 & 2002)

The physical and chemical characteristics of sediments comprising the 4H shell mounds were tested by de Wit (2001) and AMEC (2002b). Samples for both studies were collected at four locations on each mound using a vibracore that retrieved vertical cores extending from the surface, through multiple core strata, and into the underlying bottom sediment. The results of both samplings are consistent and demonstrated the presence of three distinct strata – a surface shell hash layer, a mid-mound layer of cuttings with drilling muds, and a bottom layer that consisted of the native sediments. The thickness of the individual strata varied within each mound, and in some cores one or more of the strata were absent. Shell hash consisted of 2–to 3–inch diameter shells and variable amounts of black clay, with a strong organic odor. The cuttings layer consisted of approximately 50 percent or more of fine-grained silt or clay, with fine gravel fragments or chips of siltstone, which were interpreted as cuttings particles. The bottom layer consisted of approximately 5 to 10 percent fine sand, 25 to 50 percent silt, and 30 to 35 percent clay. Some cores contained materials with a strong petroleum odor and had the appearance of free petroleum product.

Chemical analyses of samples from each of the three strata demonstrated the presence of elevated contaminant concentrations at all four of the shell mounds, as noted below. (Results from shell mound sediment testing are presented in Appendix C.)

Table 3.2-1. Characteristics of Bight '98 Sediments in the Vicinity of the 4H Shell Mounds (sampling locations are shown in Figure 3.2-1)

	BIGHT '98 BENTHIC STATIONS									
*Constituent**	*2362*	*2364*	*2365*	*2366*	*2367*	*2368*	*2369*	*2371*	*2372*	*Ave.*
Antimony	0.21	0.13	0.11	0.10	0.18	0.18	0.16	0.15	0.08	0.1
Arsenic	15	7.8	6.9	5.9	9.0	10.9	8.2	8.1	4.3	8.5
Barium	205	159	181	477	200	132	297	287	197	237
Beryllium	0.89	0.56	0.40	0.35	0.64	0.62	0.58	0.58	0.37	0.55
Cadmium	0.30	0.09	0.29	0.22	0.44	0.50	0.69	0.60	0.19	0.37
Chromium	48	20	28	26	39	38	38	34	22	33
Copper	14	3.0	9.0	8.0	20	21	22	26	9.0	15
Mercury	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Nickel	35	5.0	25	20	43	43	46	37	16	30
Lead	12	5.2	8.1	7.1	16	14	11	14	6.7	10
Silver	0.11	0.02	0.07	0.07	0.16	0.14	0.14	0.18	0.08	0.11
Selenium	2.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	0.5	1.4
Zinc	96	37	71	64	121	121	93	99	53	84
Chlordanes	0.39	0.02	0.16	0.16	0.3	0.3	0.3	0.3	0.3	0.2
DDT	20	3.9	8.3	11	13	4.5	4.4	17	2.8	9.4
PCB	5.9	0.7	1.3	3.8	0.7	0.7	0.7	0.7	0.7	1.7
LMW PAH[1]	13	5	8	9	5	5	5	5	5	7
HMW PAH[2]	64	5	5	5	42	61	58	66	5	35
TOC[3]	1.4	0.32	0.75	0.72	1.5	1.4	1.2	1.6	0.63	1.1
Fines	71	21	56	46	98	99	96	95	39	69

Notes:

* Concentrations of metals are µg/g or parts-per-million, organics are µg/kg or parts-per-billion, and TOC and fines are percent or parts-per-hundred.

1 LMWPAH = low molecular weight polycyclic aromatic hydrocarbons

2 HMWPAH = high molecular weight polycyclic aromatic hydrocarbons

3 TOC = total organic carbon

- Barium (as barium sulfate or barite) is a key component of most drilling muds. Concentrations were especially elevated in the top and middle strata (i.e., shell hash and cuttings layers) of all four mounds, while concentrations in the bottom strata were considerably lower but variable.
- Chromium was used historically with lignosulfonates as a drilling mud additive. Chromium concentrations were elevated primarily in the middle strata at each of the shell mounds.
- Lead is present in pipe dope, which was commonly used in drilling operations. Lead concentrations were elevated in the middle strata at three of the mounds and, to a lesser extent, in the surface strata at two mounds.
- Concentrations of zinc, a component of common drilling mud additives, were elevated in both the surface and middle strata at all four shell mounds.
- Nickel and vanadium, which are components of crude oil, also varied in the sediments and occasionally were present at elevated concentrations.

- Petroleum hydrocarbons (measured as total recoverable petroleum hydrocarbons [TRPH], normal [saturated] alkanes, volatile organic compounds, and PAHs) were present at highest concentrations in the middle strata of all four mounds, with lower concentrations in the surface and bottom strata.

Of greatest interest were the unusually high concentrations (up to several micrograms per gram [µg/g] or parts-per-million) of a number of volatile aromatic hydrocarbons, especially benzene, alkyl-substituted benzenes, toluene, xylenes, and naphthalene, in the middle strata samples. Unlike most metals and chlorinated hydrocarbons, these compounds are relatively soluble (i.e., readily dissolved) in seawater and, therefore, typically do not persist in marine sediments. The presence of these volatile organic compounds in the middle strata samples was consistent with visual observations and core logs noting the presence of petroleum in the sediment cores, and suggested they were derived from oil (diesel)-based drilling muds and/or crude oil adsorbed onto discarded cuttings. O'Reilly (1998) noted that oil-based drilling muds were used, albeit infrequently, at the 4H Platforms. Although volatile aromatic hydrocarbons are also associated with natural seeps (McDonald et al. 1993), the general absence of substantial concentrations of these compounds in the bottom strata suggests that they were not from natural seeps.

PCBs were also present at elevated concentrations (up to 1.6 µg/g) in sediments from three of the four mounds, and the highest concentration occurred in the surface strata from the Hope mound. PCBs may have been a component of cutting oils used during drilling or derived from other materials (e.g., capacitors) discarded from the platforms. Similarly elevated concentrations of suites of metals and petroleum hydrocarbons, typically associated with offshore oil and gas drilling operations, as well as PCBs, were measured in cores collected by de Wit (2001).

Results of acute toxicity testing (AMEC 2002b) showed that materials from all four mounds were significantly toxic to the primary test organisms (amphipods). Significant toxicity for a 10-day solid phase test using mysid shrimp was associated with three of the four sediments (Hilda, Heidi, and Hazel), whereas no toxicity was observed for 96-hour suspended phase bioassays using mysid shrimp and silverside fish (*Menidia*) as test organisms.[2] De Wit (2001) conducted 96-hour elutriate bioassay tests of shell mound sediment samples using mysid shrimp, and observed significant toxicity for the Hazel shell mound samples, whereas samples from the other three shell mounds did not indicate significant toxicity.

2 The 10-day solid phase test measures acute toxicity by exposing two different species of organisms to the sediments for 10 days with testing endpoints including survival and growth of the organisms. The solid phase bioassay tests typically use one or more species of marine amphipods because they are sensitive to benthic impacts, tolerant of a wide range of grain size and laboratory exposure conditions, and ecologically relevant to most dredged sediment disposal sites. The 96-hour "LC_{50} test" determines the median lethal concentrations of a toxic substance in the surrounding water that produces 50 percent mortality among the organisms tested over a period of 96 hours. These tests are conducted using mysid shrimp in the suspended particulate phase, which is the unfiltered supernatant extracted from a 1:9 mixture of the materials and seawater allowed to settle for one hour.

These sediment data have important implications:

- First, the elevated contaminant concentrations and significant solid-phase acute toxicity may make the materials unsuitable for disposal at the LA-2 ocean dredged material disposal site or in-place spreading.
- Second, the sediment chemistry results suggest that contaminants associated with the shell mounds are not being actively released or remobilized to the environment.

The physical and chemical characteristics of the shell mound structures also have important implications in considerations of environmental releases and the potential bioavailability of contaminants associated with the mounds. Tables 3.2-2 through 3.2-5 provide summary descriptions of sediment quality conditions at each of the four shell mounds. These issues are discussed below.

LAB-BASED SEDIMENT TESTING (2002)

Results from laboratory-based sediment testing (AMEC 2002b) demonstrated significant bioaccumulation of several metals, particularly barium, and PAHs by test organisms exposed to materials composited from each of the three shell mound strata (see Tables 3.2-2 through 3.2-5). In a separate study, soft tissues and whole organisms of selected surface-dwelling macroinvertebrate species from each of the 4H shell mounds and two reference sites were chemically analyzed for evidence of contaminant uptake from shell mound sediments (MEC 2002). Analyses of contaminant levels in infaunal organisms from the shell mounds also were attempted during this study, but they were unsuccessful because the sampling effort did not collect sufficient tissue mass for chemical analyses. Therefore, the extent of contaminant bioaccumulation in organisms living in sediments covering the shell mounds could not be evaluated.

Red and yellow rock crabs (*Cancer antennarius* and *C. anthonyi*, respectively) collected at one or more of the shell mounds contained significantly higher concentrations of several metals, including nickel, cadmium, copper, and zinc, compared with reference site specimens. Of the individual metals exhibiting significant spatial differences, some were present at elevated concentrations in the shell mound sediments whereas others were not. In particular, barium, which was elevated in shell mound sediments, was not significantly bioaccumulated by rock crabs. In contrast, tissues of bat stars (*Asterina miniata*) from the Heidi shell mound contained significantly higher barium concentrations than organisms from the reference site. Organic contaminants (e.g., petroleum hydrocarbons and PCBs) were not significantly bioaccumulated by macroinvertebrate organisms from the shell mounds, although the PCB Aroclor 1254 was detected in tissues of California sea cucumbers (*Parastichopus californicus*) from the Hazel and Hilda shell mounds (spatial differences in PCB concentrations in this species could not be evaluated statistically because no specimens were collected at the reference sites).

The source of the PCBs in tissues of California sea cucumbers and the elevated concentrations of selected metals in rock crabs and bat star tissues could not be determined. The overall results did not indicate consistent differences between shell

Table 3.2-2a. Hope Shell Mound Material Summary (AMEC 2002b)

Visual Observations/ Field Logs	Visual observations and field logs from coring operations conducted in May 2002 indicated a surface layer from 3 to 6.5 ft (1 to 2 m) thick, consisting largely of shell hash with some silty mud. Under the surface shell hash layer were strata up to 12.5 ft (3.8 m) thick containing drill cuttings and mud with a detectable petroleum odor. The bottom layer consisted primarily of native clay sand sediments.
Summary of Chemistry and Grain Size Data Analyses	Standard testing of the shell mound sediments showed total sulfides concentrations from 94 to 430 µg/g in the Hope strata samples and 450 µg/g in the composite sample, whereas soluble sulfides were not detected. Total organic carbon concentrations ranged from 0.29 to 0.52 percent in the individual strata samples and 0.45 percent in the composite sample. Ammonia concentrations ranged from 15 to 24 µg/g in the strata samples and 15 µg/g in the composite. The shell mound materials contained approximately 35 to 40 percent moisture by weight. Concentrations of metals and petroleum hydrocarbons in the sediments are summarized in Table 3.2-2b. All three strata contained elevated barium concentrations (992 to 5,370 µg/g), indicative of the presence of drilling muds. The middle strata also contained elevated concentrations of chromium (135 µg/g), lead (79 µg/g), and zinc (575 µg/g). Petroleum hydrocarbons, especially volatile organic compounds and PAHs, were appreciably higher in the middle strata sediments than in the surface and, to a much greater degree, bottom strata. The presence of volatile organic compounds in the middle strata reflected the presence of non-weathered (i.e., degraded) petroleum that was visible in the cores. With the exception of detectable quantities of PCB Aroclor 1254, 2,4-dinitrophenol, and bis-2-ethylhexylphthalate, chlorinated pesticides, phenols, and phthalate esters were generally nondetectable. PCB (Aroclor 1254) concentrations were highest (1.6 µg/g) in the surface strata, relatively lower in the middle strata and composite samples (0.056 and 0.40 µg/g, respectively), and nondetectable in the bottom strata. The 2,4-dinitrophenol occurred only in the middle strata (0.032 µg/g), while bis-2-ethylhexylphthalate occurred in both the surface and middle strata (0.043 and 0.039 µg/g, respectively).
Summary of Chemistry Toxicity and Bioaccumulation Data Analyses	The composite sediment core from the shell mound produced significant acute toxicity (61 percent survival of amphipods) in the 10-day solid phase test, but no significant toxicity for the suspended particulate phase tests. Bioaccumulation test results indicated statistically elevated barium concentrations in test clam tissues, and elevated barium, mercury, and molybdenum concentrations in test worm tissues. The test clam and worm tissues also contained significantly higher PAH concentrations (total PAHs as well as individual parent and alkyl-substituted compounds) than those in the reference organisms. In contrast, PCB and chlorinated pesticide concentrations in test tissues were not significantly different from those in reference tissues.

Table 3.2-2b. Concentrations of Metals and Petroleum Hydrocarbons in the Top, Middle, and Bottom Strata and Strata Composite of Hope Shell Mound Sediments

HOPE				
METALS (µg/g)				
Metal/Constituent	*Top*	*Middle*	*Bottom*	*Composite*
Antimony	ND	ND	ND	ND
Arsenic	2.19	3.47	4.93	3.23
Barium	4440	5370	992	5490
Beryllium	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND
Chromium	19.2	135	35.5	49.0
Cobalt	1.61	2.51	6.95	3.03
Copper	8.24	28.6	13.7	16.6
Mercury	0.098	0.145	ND	0.086
Lead	15.5	79.0	12.4	28.6
Molybdenum	2.03	2.13	ND	1.53
Nickel	7.99	15.5	29.2	15.5
Selenium	ND	ND	ND	ND
Silver	ND	ND	ND	ND
Thallium	ND	ND	ND	ND
Vanadium	12.4	14.5	48.4	20.3
Zinc	418	575	134	493
PETROLEUM HYDROCARBONS (µg/g)				
TRPH	360	800	160	570
Total C7-C40 Alkanes	8.4	86	ND	ND
VOLATILE ORGANIC COMPOUNDS (µg/kg)				
Benzene	ND	3.6	ND	ND
n-Butylbenzene	5.1	35	ND	13
sec-Butylbenzene	9.2	43	ND	20
Ethylbenzene	7.4	73	ND	27
Isopropylbenzene	19	110	ND	45
n-propylbenzene	46	300	ND	110
1,2,4-Trimethylbenzene	140	890	ND	360
1,3,5-Trimethylbenzene	63	390	ND	160
Toluene	4.3	38	ND	17
p/m-Xylene	20	170	ND	64
o-Xylene	26	150	ND	62
Naphthalene	ND	140	790	52
PAHS (µg/kg)				
Naphthalene	ND	130	ND	ND
Phenanthrene	ND	110	ND	150
Acenaphthene	ND	46	ND	ND
Pyrene	78	44	ND	ND
Fluorene	ND	57	ND	ND
Note: ND = not detected				

Table 3.2-3a. Hazel Shell Mound Material Summary (AMEC 2002b)

Visual Observations/ Field Logs	Visual observations and field logs from coring operations in May 2002 indicated a surface layer up to 7 ft (2 m) thick, with variable amounts of shell hash and silt and an oil sheen in one of the four cores. Under the surface layer was a stratum up to 12 ft (3.6 m) thick containing drill cuttings and mud with a detectable petroleum odor. The bottom layer consisted primarily of native clay sand sediments.
Summary of Chemistry and Grain Size Data Analyses	Standard testing of the Hazel shell mound sediments showed total sulfides concentrations from nondetectable to 43 µg/g in the individual strata samples and 23 µg/g in the composite sample, whereas soluble sulfides were not detected. Total organic carbon concentrations ranged from 0.41 to 0.98 percent in the individual strata samples and 0.67 percent in the composite sample. Ammonia concentrations ranged from 26 to 51 µg/g in the strata samples and 54 µg/g in the composite. The shell mound materials contained approximately 30 to 50 percent moisture by weight. Concentrations of metals and petroleum hydrocarbons are summarized in Table 3.2-3b. All three strata contained elevated barium concentrations (1,620 to 4,030 µg/g), and the middle strata also contained elevated concentrations of chromium (101 µg/g), lead (110 µg/g), and zinc (343 µg/g). Petroleum hydrocarbons, especially the volatile organic compounds, were higher in the middle strata sediments than in the surface and bottom strata although, unlike the other shell mound samples, appreciable quantities of several volatile organic compounds were also present in the bottom stratum. With the exception of detectable quantities of Aroclor 1254 and bis-2-ethylhexylphthalate, chlorinated pesticides, phenols, and phthalate esters were generally nondetectable in the Hazel shell mound sediments. PCBs (Aroclor 1254) occurred in both the surface and middle strata (0.16 and 0.15 µg/g, respectively) and composite (0.13 µg/g) samples, but were nondetectable in the bottom stratum. The bis-2-ethylhexylphthalate occurred only in the surface stratum (0.13 µg/g).
Summary of Toxicity and Bioaccumulation Data Analyses	The composite sediment core from the Hazel shell mound produced significant acute toxicity for both the 10-day solid phase tests (33 percent survival of amphipods and 84 percent survival of mysids), but no significant toxicity for the suspended particulate phase tests. Bioaccumulation test results indicated statistically elevated barium, chromium, and lead concentrations in test clam tissues and elevated barium and molybdenum concentrations in test worm tissues. The test clam and worm tissues also contained significantly higher PAH concentrations (total PAHs as well as individual parent and alkyl-substituted compounds) than those in the reference organisms. In contrast, concentrations of PCBs and chlorinated pesticides in test tissues were not significantly different from those in reference tissues.

Table 3.2-3b. Concentrations of Metals and Petroleum Hydrocarbons in the Top, Middle, and Bottom Strata and Strata Composite of Hazel Shell Mound Sediments

HAZEL				
METALS (µg/g)				
Metal/Constituent	*Top*	*Middle*	*Bottom*	*Composite*
Antimony	2.12	ND	ND	ND
Arsenic	4.81	9.34	5.87	7.32
Barium	4030	3670	1620	4220
Beryllium	ND	ND	ND	ND
Cadmium	ND	1.87	ND	2.39
Chromium	67.0	101	43.8	82.6
Cobalt	5.48	4.83	6.79	4.80
Copper	19.8	33.5	8.84	33.2
Mercury	0.053	0.084	ND	0.074
Lead	30.0	110	14.8	95.2
Molybdenum	4.43	7.10	ND	5.19
Nickel	32.4	54.1	35.9	63.3
Selenium	2.35	1.86	ND	1.65
Silver	ND	ND	ND	ND
Thallium	ND	ND	ND	ND
Vanadium	45.8	45.4	50.2	42.8
Zinc	611	343	157	377
PETROLEUM HYDROCARBONS (µg/g)				
TRPH	280	440	30	490
Total C7-C40 Alkanes	48	130	ND	100
VOLATILE ORGANIC COMPOUNDS (µg/kg)				
Benzene	ND	230	240	180
n-Butylbenzene	ND	320	180	380
sec-Butylbenzene	ND	150	94	200
Ethylbenzene	ND	410	350	500
Isopropylbenzene	ND	140	110	180
n-propylbenzene	ND	250	180	320
1,2,4-Trimethylbenzene	ND	2200	1400	2700
1,3,5-Trimethylbenzene	ND	570	380	640
Toluene	ND	430	410	400
p/m-Xylene	ND	2100	1600	2200
o-Xylene	ND	710	580	790
Naphthalene	ND	1300	790	1500
PAHS (µg/kg)				
Naphthalene	ND	1700	ND	1100
Phenanthrene	ND	ND	ND	150
Acenaphthene	ND	ND	ND	ND
Pyrene	1330	ND	ND	ND
Fluorene	ND	ND	ND	ND
Note: ND = not detected				

1 **Table 3.2-4a. Heidi Shell Mound Material Summary (AMEC 2002b)**

Visual Observations/ Field Logs	Visual observations and field logs from coring operations in May 2002 indicated a surface layer from 2 to 6 ft (0.6 to 1.8 m) thick consisting largely of shell hash with some silty mud and a petroleum odor. Under the surface shell hash layer was a 2 to 9 ft (0.6 to 2.7 m) thick strata containing drill cuttings and mud with some loose sand and a detectable petroleum odor. The bottom layer consisted primarily of native clay sediments.
Summary of Chemistry and Grain Size Data Analyses	Standard testing of the shell mound sediments showed total sulfides concentrations from 1.7 to 81 µg/g in the individual strata samples and 10 µg/g in the composite sample, whereas soluble sulfides were not detected. Total organic carbon concentrations ranged from 0.18 to 0.56 percent in the individual strata samples and 0.50 percent in the composite sample. Ammonia concentrations ranged from 31 to 40 µg/g in the strata samples and 41 µg/g in the composite. The shell mound materials contained approximately 30 to 35 percent moisture by weight. Concentrations of metals and petroleum hydrocarbons in the sediments are summarized in Table 3.2-4b. The top and middle strata contained elevated barium concentrations (4,790 and 5,530 µg/g, respectively), indicative of the presence of drilling muds. The middle layer and composite samples also contained elevated concentrations of chromium (119 and 68 µg/g, respectively), and zinc (498 and 372 µg/g, respectively). Petroleum hydrocarbons, especially TRPH, PAHs, and the volatile organic compounds, were higher in the middle layer sediments than in the top and bottom layers. With the exception of detectable quantities of bis-2-ethylhexylphthalate, chlorinated pesticides, phenols, and phthalate esters were generally nondetectable; bis-2-ethylhexylphthalate occurred only in the surface layer (0.06 µg/g). Unlike the other shell mound samples, PCBs were not detected in any of the individual strata or composite Heidi samples.
Summary of Chemistry and Grain Size Data Analyses	The composite sediment core from the Heidi shell mound produced significant acute toxicity for the 10-day solid phase test (62 percent survival of amphipods and 70 percent survival of mysids), but no significant toxicity for the suspended particulate phase tests. Bioaccumulation test results indicated statistically elevated barium concentrations in test clam tissues, and elevated barium and molybdenum concentrations in test worm tissues. The test clam and worm tissues also contained significantly higher PAH concentrations (total PAHs as well as individual parent and alkyl-substituted compounds) than those in the reference organisms. In contrast, concentrations of PCBs and chlorinated pesticides in test clam and worm tissues were not significantly different from those in the corresponding reference tissues.

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Table 3.2-4b. Concentrations of Metals and Petroleum Hydrocarbons in the Top, Middle, and Bottom Strata and Strata Composite of Heidi Shell Mound Sediments

HEIDI				
METALS (µg/g)				
Metal/Constituent	*Top*	*Middle*	*Bottom*	*Composite*
Antimony	2.12	ND	ND	ND
Arsenic	3.06	3.14	5.38	2.93
Barium	4790	5530	348	3870
Beryllium	ND	ND	ND	ND
Cadmium	ND	ND	ND	2.39
Chromium	46.8	119	36.1	67.6
Cobalt	4.06	3.02	7.91	3.31
Copper	26.2	11.9	12.0	10.4
Mercury	0.033	ND	0.049	0.050
Lead	16.5	16.3	11.4	12.6
Molybdenum	4.92	ND	ND	ND
Nickel	18.9	17.0	33.0	16.7
Selenium	ND	ND	ND	ND
Silver	ND	ND	ND	ND
Thallium	ND	ND	ND	ND
Vanadium	29.6	17.5	50.5	21.7
Zinc	424	498	85.6	372
PETROLEUM HYDROCARBONS (µg/g)				
TRPH	49	330	41	280
Total C7-C40 Alkanes	ND	250	ND	120
VOLATILE ORGANIC COMPOUNDS (µg/kg)				
Benzene	ND	ND	ND	ND
n-Butylbenzene	ND	330	ND	160
sec-Butylbenzene	ND	170	ND	89
Ethylbenzene	ND	290	ND	210
Isopropylbenzene	ND	400	ND	230
n-propylbenzene	ND	1100	ND	600
1,2,4-Trimethylbenzene	ND	4100	ND	2400
1,3,5-Trimethylbenzene	ND	1600	ND	840
Toluene	ND	33	ND	37
p/m-Xylene	ND	760	ND	490
o-Xylene	ND	550	ND	360
Naphthalene	ND	4400	790	1600
PAHS (µg/kg)				
Naphthalene	ND	ND	ND	ND
Phenanthrene	ND	390	ND	150
Acenaphthene	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND
Note: ND = not detected				

Table 3.2-5a. Hilda Shell Mound Material Summary (AMEC 2002b)

Visual Observations/ Field Logs	Visual observations and field logs from coring operations indicated a surface layer of 0.5 to 5 ft (0.2 to 1.5 m) consisting largely of shell hash, with an oil sheen and petroleum odor (AMEC 2002b). Under this shell hash layer was a middle stratum up to 21 ft (6.4 m) thick containing drill cuttings and mud with some gravel, shell debris, and a detectable petroleum odor. The bottom layer consisted primarily of native clay sediments.
Summary of Chemistry and Grain Size Data Analyses	Standard testing of the shell mound sediments showed total sulfides concentrations from 22 to 1,000 µg/g in the individual strata samples and 20 µg/g in the composite sample, whereas soluble sulfides were not detected. Total organic carbon concentrations ranged from 0.70 to 1.2 percent in the individual strata samples and 0.82 percent in the composite sample. Ammonia concentrations ranged from 31 to 100 µg/g in the strata samples and 39 ppm in the composite. The shell mound materials contained approximately 30 to 40 percent moisture by weight. Concentrations of metals and petroleum hydrocarbons are summarized in Table 3.2-5b. The top and middle strata contained elevated barium concentrations (3,210 and 2,420 µg/g, respectively), the middle layer and composite samples contained elevated chromium (105 and 56 µg/g, respectively) and zinc (287 and 468 µg/g, respectively) concentrations, and lead concentrations (77 µg/g) were elevated in the middle stratum. Petroleum hydrocarbons, especially TRPH and the volatile organic compounds, were higher in the top and middle strata sediments than in the bottom stratum. With the exception of detectable quantities of PCBs (Aroclor 1254) and bis-2-ethylhexylphthalate, most chlorinated pesticides, phenols, and phthalate esters were generally nondetectable. The bis-2-ethylhexylphthalate occurred only in the top stratum (0.06 µg/g), while Aroclor 1254 occurred in both the top and middle strata (0.22 and 0.18 µg/g, respectively).
Summary of Toxicity and Bioaccumulation Data Analyses	The composite sediment core from the Hilda shell mound produced significant acute toxicity for both 10-day solid phase tests (66 percent survival of amphipods and 82 percent survival of mysids), but no significant toxicity for the suspended particulate phase tests. Bioaccumulation test results indicated statistically elevated barium concentrations in test clam tissues, and elevated barium and molybdenum concentrations in test worm tissues. The test clam and worm tissues also contained significantly higher PAH concentrations (total PAHs as well as individual parent and alkyl-substituted compounds) than those in the reference organisms. In contrast, concentrations of PCBs and chlorinated pesticides in test clam and worm tissues were not significantly different from those in the corresponding reference tissues.

Table 3.2-5b. Concentrations of Metals and Petroleum Hydrocarbons in the Top, Middle, and Bottom Strata and Strata Composite of Hilda Shell Mound Sediments

HILDA				
METALS (µg/g)				
Metal/Constituent	*Top*	*Middle*	*Bottom*	*Composite*
Antimony	ND	ND	ND	ND
Arsenic	3.97	5.11	4.52	4.73
Barium	3210	2420	549	5320
Beryllium	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND
Chromium	45.2	105	28.5	56.5
Cobalt	3.41	4.34	4.96	4.51
Copper	21.4	17.1	10.2	12.9
Mercury	0.055	ND	0.043	0.033
Lead	30.4	77.3	7.40	14.2
Molybdenum	2.74	5.03	ND	2.55
Nickel	19.1	38.5	26.2	30.3
Selenium	ND	2.53	ND	1.91
Silver	ND	ND	ND	ND
Thallium	ND	ND	ND	ND
Vanadium	23.8	40.5	33.0	40.4
Zinc	379	287	87.8	468
PETROLEUM HYDROCARBONS (µg/g)				
TRPH	2400	3300	290	1200
Total C7-C40	ND	100	ND	ND
VOLATILE ORGANIC COMPOUNDS (µg/kg)				
Benzene	7.1	150	ND	39
n-Butylbenzene	10	57	ND	14
sec-Butylbenzene	7.7	52	ND	12
Ethylbenzene	5.9	230	ND	48
Isopropylbenzene	6.1	75	ND	18
n-propylbenzene	14	160	ND	37
1,2,4-Trimethylbenzene	27	3300	ND	190
1,3,5-Trimethylbenzene	11	240	ND	62
Toluene	3.4	67	ND	12
p/m-Xylene	17	560	ND	100
o-Xylene	8.7	220	ND	41
Naphthalene	ND	280	ND	62
PAHS (µg/kg)				
Naphthalene	ND	ND	ND	ND
Phenanthrene	ND	390	ND	150
Acenaphthene	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND
Note: ND = not detected				

mound and reference site organisms in the magnitude of those shell mound-related contaminants with the greatest potential for bioaccumulation, such as those measured in the sediment testing study. The presence of detectable PCBs in California sea cucumber tissues demonstrated that some human-derived contaminants are present in the vicinity of the 4H shell mounds and biologically available, although the specific source(s) of these contaminants is unknown.

Differences between the laboratory-based bioaccumulation testing (AMEC 2002b) and field-based exposure studies (MEC 2002) likely reflect several factors such as:

1. species used for the field study are mobile and their exposure histories (i.e., residency) and equilibrium status relative to exposure conditions are unknown; and
2. the laboratory bioaccumulation testing used core (composited) materials from all three shell mound strata, whereas macroinvertebrates from the field study were exposed only to the exterior portions of the mounds, which may have contaminant concentrations that are considerably lower from those in the inner portions of the mounds.

MUSSEL STUDY (2003)

A caged mussel bioassay study (SAIC 2003; Appendix G) at the 4H shell mounds was conducted in 2003 to evaluate whether and to what extent chemical contaminants were leaching from the mounds and the potential for adverse biological effects if leaching was occurring. The study results showed that all of the shell mound mussel samples exhibited significant growth, as indicated by increases in shell length, whole animal and soft tissue mass, and tissue lipid content. In some cases, growth metrics for the shell mound samples were significantly higher than those for the reference sites. Mussel survival was greater than 90 percent at all sites, and there were no significant differences in survival rates between shell mound and corresponding reference sites.

Statistical analyses of mussel tissue concentration data did not indicate significantly higher levels in the shell mound samples than the reference site samples for any of the chemical analytes. While the previous testing of sediment cores showed high concentrations of several chemical contaminants, such as metals, petroleum hydrocarbons, and PCBs in the shell mounds, results from the mussel bioassays demonstrated that these contaminants are not being released in measurable amounts into overlying waters. These results are consistent with the presence of the contaminant classes that are susceptible to chemical degradation, such as volatile aromatic hydrocarbons, in the middle strata of the mounds. Because these aromatic compounds are water soluble with low affinities for particles, it is unlikely that they would have persisted for more than 30 years in the shell mounds if active exchange with overlying waters is occurring. Instead, the soluble contaminants as well as other more hydrophobic contaminants have persisted in the shell mounds for several decades, and it does not appear that the contaminants are susceptible to much, if any, remobilization from the shell mounds during normal or severe storm conditions.

BOTTOM SEDIMENT ASSESSMENTS

Bascom et al. (1976) reported concentrations of copper (12 to 14 µg/g) and zinc (61 to 68 µg/g) in bottom sediments near Platform Hilda during 1975 (i.e., prior to platform removal) that were comparable to concentrations in sediments from a control area. In 2003, the grain size and chemical characteristics of bottom sediments at distances of 330 and 990 ft (100 m and 300 m) from each of the 4H shell mounds were evaluated (SAIC 2003; Appendix G). These assessments indicated some minor and localized variations in grain size and chemical characteristics, including elevated barium concentrations, compared with those at a reference area. These changes likely were related to a non-uniform distribution of drilling-related solids. However, barium concentrations did not exhibit clear spatial gradients with distance from the shell mounds. Instead, the highest barium concentrations occurred at varying distances and directions at different mound sites. These patterns likely reflected distributions of drilling waste solids near the shell mounds that may have been related to events such as platform removal, vessel/barge anchoring, and/or fish trawling, that resulted in physical disturbances and displaced solids (e.g., cuttings) from the mounds rather than dispersion of shell mound solids by local currents. Regardless, the presence of shell mound solids contributed to the present heterogeneity of sediment quality near each of the shell mounds. Other sediment quality characteristics, including total organic carbon and concentrations of most metals and organic contaminants, in surface sediments near the shell mounds were comparable to those at reference sites and other adjacent locations within this portion of the Channel.

Conditions at LA-2 Ocean Dredged Material Disposal Site

Sediment quality within LA-2 is characterized by USEPA (1988). Additionally, results of chemical and physical analyses of sediments from the LA-2 Reference Sites as part of the 4H shell mounds sediment testing (AMEC 2002b), are provided in Appendix C.

3.2.2 Regulatory Setting

Several federal and State statutes play important roles in protecting ocean and coastal waters. Relevant statutes are summarized below.

Clean Water Act

The Federal Water Pollution Control Act and subsequent amendments, collectively known as the Clean Water Act (CWA) (33 USC section 1251 et seq.), were enacted by Congress to restore and maintain the chemical, physical, and biological integrity of U.S. waters. The CWA prohibits the discharge of oil or hazardous substances in Territorial Waters (i.e., to 12 nm [22 km]) in quantities harmful to public health or welfare or to the environment. The Act also created the National Pollutant Discharge Elimination System (NPDES) of permits that specifies minimum water quality standards for discharged wastewaters, requires states to establish standards specific to water bodies, and designates the types of pollutants to be regulated, including suspended solids and oils. Under NPDES, all point sources that discharge directly into waterways are required to

obtain a permit regulating their discharge. Each permit specifies effluent limitations for particular pollutants, and monitoring and reporting requirements for the proposed discharge.

As required by the CWA, the USEPA (1996) developed National Ambient Water Quality Criteria (NAWQC), which establish numerical maximum concentration levels for contaminants in discharges to surface waters for the protection of both ecological and human health. The criteria, which apply to Territorial Waters, are not rules and they do not have regulatory effect; however, they can be used to develop regulatory requirements based on concentrations that will have an adverse impact on the qualities necessary for existing beneficial uses of U.S. waters.

Marine Protection, Research and Sanctuary Act

The Marine Protection, Research, and Sanctuaries Act (MPRSA, also known as the "Ocean Dumping Act") (33 USC section 1401 et seq.) regulates the transport of materials for the purpose of dumping in ocean waters. MPRSA would apply to disposal of shell mound materials at a designated ocean dredged material disposal site such as LA-2. Dredged material proposed for disposal at aquatic sites must undergo testing to determine its potential effects on the disposal site environment, and whether it is suitable for unconfined aquatic disposal. For ocean disposal sites, these testing requirements are defined in 40 CFR 227.6. Guidance on implementing these regulations is provided in *Evaluation of Dredged Material Proposed for Ocean Disposal—Testing Manual* (USEPA/USACE 1991), known as the Green Book, which is promulgated under the MPRSA.

The Porter-Cologne Water Quality Control Act (Porter-Cologne Act)

The Porter-Cologne Act (California Water Code section 13000 et seq.), which is the principal law governing water quality regulation in California, establishes a comprehensive program to protect water quality and the beneficial uses of State waters. The Act established the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCBs), which are charged with implementing its provisions and which have primary responsibility for protecting water quality in California. The Porter-Cologne Act also implements many provisions of the federal CWA, such as the NPDES permitting program. CWA section 401 gives the SWRCB the authority to review any proposed federally permitted or federally licensed activity which may impact water quality and to certify, condition, or deny the activity if it does not comply with State water quality standards. If the SWRCB imposes a condition on its certification, those conditions must be included in the federal permit or license.

California Ocean Plan

The California Ocean Plan (SWRCB 2001) establishes water quality objectives for California's ocean waters and provides the basis for regulation of wastes discharged into the State's ocean and coastal waters. The SWRCB prepares and adopts the Ocean Plan, which incorporates the State water quality standards that apply to all NPDES

permits for discharges to ocean waters, and both the SWRCB and the six coastal RWQCBs implement and interpret the Ocean Plan. The Ocean Plan is not applicable to vessel wastes or the control of dredged material (Ocean Plan Introduction, Section C.2).

Basin Plan

The Central Coast RWQCB Water Quality Control Plan (Basin Plan) for coastal waters, which includes the areas of the 4H shell mounds, has three components: beneficial uses which are to be protected, water quality objectives which protect those uses, and an implementation plan which accomplishes those objectives (see California Water Code [CWC] section 13050). The Central Coast RWQCB's Basin Plan standards incorporate the applicable portions of the California Ocean Plan and are more specific to the beneficial uses of marine waters adjacent to the project site. These water quality objectives and toxic material limitations are designed to protect the beneficial uses of ocean waters shown in Table 3.2-6. Along with the Ocean Plan provisions, the Central Coast RWQCB Basin Plan specifies additional objectives applicable to all ocean waters, including: (1) the mean annual DO concentration shall not be less than 7.0 mg/L, nor shall the minimum DO concentration be reduced below 5.0 mg/L at any time; and (2) the pH value shall not be depressed below 7.0, nor raised above 8.5.

3.2.3 Significance Criteria

An impact to marine water quality or sediment quality would be significant if the action:

- Violates any water quality standards or waste discharge requirements;
- Creates turbidity, dissolved oxygen demand, contaminants, or other conditions that would result in substantial mortality of aquatic organisms;
- Otherwise substantially degrades water or sediment quality;
- Exposes aquatic organisms to contaminant concentrations with the potential for causing acute toxicity and/or bioaccumulation;
- Alters water circulation to the extent that persistent adverse effects on water quality result.

Potential impacts to marine water and sediment quality associated with the Program Alternatives, including the No Project Alternative, are evaluated relative to these significance criteria in the following sections.

3.2.4 Impacts and Mitigation Measures

The potential for impacts to marine water and sediment quality varies for each of the component actions and Program Alternatives identified in Table 1-1. Shell mound removal alternatives may involve disturbances to water quality associated with resuspension of mound materials and natural bottom sediments, contaminant releases from dredged materials and decant waters, exposures of aquatic organisms to toxic and/or bioaccumulative substances, and redeposition of residual mound materials and

Table 3.2-6. Beneficial Uses of Waters in the Vicinity of the 4H Shell Mounds (RWQCB 1994)

Water Contact Recreation (REC-1)	Uses of water for recreational activities involving body contact for water, where ingestion of water is reasonably possible. These uses include but are not limited to swimming, wading, water skiing, skin and scuba diving, surfing, and fishing.
Non-Contact Water Recreation (REC-2)	Uses of water for recreational activities involving proximity to water but not normally involving body contact with water, where ingestion of water is not reasonably possible. These uses include but are not limited to picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, and aesthetic enjoyment in conjunction with the above activities.
Industrial Service Supply (IND)	Uses of water for industrial activities that do not depend primarily on water quality including but not limited to mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.
Navigation (NAV)	Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.
Marine Habitat (MAR)	Uses of water that support marine ecosystems including but not limited to preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife such as marine mammals and shorebirds.
Shellfish Harvesting (SHELL)	Uses of water that support habitats suitable for the collection of filter-feeding shellfish such as clams, oysters, and mussels, for human consumption, commercial, or sport purposes. This includes water that may have in the past or may in the future contain significant shellfisheries.
Ocean Commercial and Sport Fishing (COMM)	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including uses involving organisms intended for human consumption or bait purposes.
Rare, Threatened, or Endangered Species (RARE)	Uses of water that support habitats necessary at least in part for the survival and successful maintenance of plant or animal species established under state or federal laws as rare, threatened, or endangered.
Wildlife Habitat (WILD)	Uses of water that support terrestrial ecosystems including but not limited to preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

associated contaminants on the seafloor. Shell mound modification alternatives may involve placing clean sediments or reef materials over and around the mounds, with potential impacts to water quality associated with elevated turbidity and suspended sediment concentrations, as well as disturbances of shell mound materials during cap placement or reef construction. The Offsite Mitigation and No Project Alternatives would result in the shell mounds remaining in place. Potential impacts to water quality from leaving the shell mounds in place are primarily related to the long-term risks that contaminants could be released to the marine environment if the mounds were physically disturbed by outside sources (e.g., anchors or trawl nets) or by natural decomposition (e.g., sloughing), with subsequent exposures of resident biota to toxic and/or bioaccumulative substances.

The following sections address potential impacts to marine water and sediment quality associated with each of the Program Alternatives. Impacts are identified in summary tables, along with the location of the impact and impact class (defined in Section 3.0). Following each summary table, the impacts are described, measures to mitigate potentially significant adverse impacts are identified, and "residual impacts" (impacts following implementation of mitigation measures) are discussed. Less-than-significant impacts (Class III) and beneficial impacts (Class IV) are described where appropriate. Table 3.2-8, at the end of this Section, provides a summary of impacts to marine water and sediment quality, corresponding mitigation measures, and impact classes.

3.2.4.1 Program Alternative 1 (PA1): Shell Mounds and Caissons Removal and Disposal

PA1 would remove and dispose of the 4H shell mounds and caissons at the Hazel shell mound.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA1	**WQ-1**	Removal of the 4H shell mounds would permanently remove contaminated sediments associated with the shell mounds from the marine environment.	Offshore Santa Barbara County (shell mound sites)	IV

Impacts: Permanent Removal of Contaminated Sediments

Complete removal of the 4H shell mounds could result in a beneficial long-term impact if contaminants associated with the shell mound sediments were entering, or could later enter, the marine environment. As discussed in Section 3.2.1.3, results from the caged mussel bioassay study (Appendix G) demonstrate that contaminants are not presently leaching from the 4H shell mounds. Existing information also suggests that contaminants associated with platform discharges have not been altered substantially since the discharges were discontinued in the 1970s. Unless the mounds are physically disturbed or otherwise altered, and the buried contaminants in the mounds are exposed, the potential for contaminant leaching from the mounds to the marine environment is not expected to change.

Removal of the shell mounds would eliminate risks of potentially adverse impacts to water and sediment quality that could occur if the shell mounds were left in place and later disturbed by natural (e.g., storms, animal burrowing, subsidence) or human causes (e.g., trawling, anchoring). Specific impacts could include the following:

- Releases of soluble contaminants, especially lower molecular weight aromatic hydrocarbons and free product (petroleum), to waters above the mounds;
- Acute toxicity and contaminant bioaccumulation in bottom-dwelling organisms exposed to dispersed mound materials; and
- Formation of an oil slick or sheen on the water surface from release/spills of petroleum hydrocarbons associated with shell mound materials.

Therefore, the available data suggest that the potential beneficial impacts to marine water quality and sediment quality from removing the shell mounds derive from eliminating the potential long-term risks of contaminant releases that could occur following future disturbances of the mounds rather than from reducing the present rate or magnitude of contaminant release.

MITIGATION MEASURES FOR IMPACT WQ-1

None proposed.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA1	**WQ-2**	Dredging-related operations will, to varying degrees of impact, disturb and resuspend shell mound materials resulting in: (1) elevated levels of suspended solids and increased turbidity (reduced water clarity/light transmittance), (2) release of soluble contaminants, especially lower molecular weight aromatic hydrocarbons and free product (petroleum) to waters above the shell mounds; (3) formation of an oil slick or sheen on the water surface from releases of petroleum hydrocarbons contained in the mounds; and (4) potential exceedances of water quality standards or objectives.	Offshore Santa Barbara County (shell mound sites). This impact could affect water quality within several hundred feet of the dredge and dewatering barge.	II / III

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA1 *cont.*	**WQ-2 *cont.***	Specific activities include:		
		• Dredging, including barge loading;		II
		• Dewatering;		II
		• Final site smoothing;		II
		• Hazel caissons removal (after shell mound removal);		III
		• Anchoring.		III

Impacts: Dredging and Dewatering

SUSPENDED SOLIDS/TURBIDITY EFFECTS ON WATER CLARITY/LIGHT TRANSMITTANCE

During removal of the shell mounds, activities such as dredging, loading dredged materials onto barges, and dewatering will cause elevated suspended sediment concentrations and generate turbidity plumes near the shell mounds and barges, with accompanying decreases in light transmittance. A plume of turbid water containing high suspended sediment concentrations can occur throughout the water column (i.e., from the surface to the bottom), depending on the source of the suspended particles and the rates of particle sinking and dispersion. For example, bottom sediments suspended during dredging are expected to remain in the near-bottom water depths and, therefore, would not cause a visible surface plume. In contrast, sediments released to surface waters from the dredge bucket during barge loading are expected to form a visible plume in the surface layers.

Turbidity plumes are expected to persist for the duration of the dredging operation at each mound. Based on information provided in Section 2.2.1, dredging at all four mound sites is estimated to last 9 days (assuming 24-hour dredging operations and not including an additional day per mound to move operations to the next mound). Following completion of dredging and final site smoothing (see below), the suspended sediment/turbidity plume is expected to disperse within hours due to mixing, dilution, and settling of dredged solids. Thus, water quality impacts related to elevated suspended solids concentrations and turbidity levels from dredging operations are expected to be temporary and localized to the vicinity of the dredging sites.

The enclosed bucket dredge is considered the best method for removing the mound materials because it would minimize the loss to adjacent waters at the dredging site of dredged solids, which is the primary contributor to the turbidity plume (Hayes 1986), as well as minimize releases of soluble contaminants and free product (crude oil) associated with the mound materials. Previous studies (Welp et al. 2001) demonstrated that suspended solids concentrations and turbidity levels associated with dredging operations using an enclosed bucket dredge were relatively lower than those associated with a conventional bucket dredge. For example, during dredging operations using an enclosed bucket, suspended solids concentrations within 26 ft (8 m) of the dredge, averaged over the water column, were 50 mg/L (parts-per-million) compared to concentrations of 210 mg/L associated with a conventional bucket dredge. However,

when debris was encountered that prevented the enclosed bucket from closing properly, suspended solids concentrations greater than 200 mg/L occurred. Hayes (1986) reported suspended solids concentrations ranging from 50 to 300 mg/L at 100 ft (30 m); 40 to 210 mg/L at 200 ft (60 m); and 25 to 100 mg/L at 400 ft (120 m) from an enclosed bucket dredging operation. The magnitude of suspended sediment releases to site waters can also be controlled somewhat by removing large pieces of debris that prevent the bucket from closing and by slowing the bucket retrieval rate, although these actions would reduce the production rate of the dredge and prolong the dredging operation proportionately.

Discharges of decant waters from the dewatering barge would also form a plume around the dredge/barge, with elevated suspended sediment concentrations and turbidity conditions. Based on an estimated volume of 45,000 cy (34,000 cubic meters) for all 4H shell mounds (9,300 to 18,500 cy or 7,000 to 14,000 cubic meters per mound), and moisture content of 30 percent by volume (not including the volume of water in the dredge bucket), the maximum decant water volume would be approximately 13,500 cy (10,200 cubic meters) if all four mounds were dredged and all of the pore water/moisture were removed. In practice, the dewatering objective would be 50 percent moisture, which would result in an approximate decant water volume of 6,700 cy (5,000 cubic meters), with a maximum of 2,800 cy (2,100 cubic meters) of water per mound. Any overflow or discharge of decant waters would require a Waste Discharge Requirement (WDR) issued by the RWQCB. The RWQCB typically assigns maximum settleable solids concentrations for decant waters of 1 ml/L, but generally assumes that the plume will mix to background within a 330 ft (100 m) radius of the dewatering barge. Decant waters would mix and dilute rapidly with site waters.

RELEASE OF SOLUBLE CONTAMINANTS

The shell mounds contain some chemically reduced substances that, when released to site waters, would exert an oxygen demand. However, because waters near the shell mounds are well-oxygenated, releases of shell mound materials are not expected to reduce the DO concentrations to levels that adversely affect aquatic organisms. Since sediments within the shell mounds contain elevated concentrations of chemical contaminants, and several layers of muds and cuttings also contain oily sheens and petroleum odors (de Wit 2001), dredging operations are expected to release both particulate- and soluble-phase contaminants to the water column.[3]

Discharges of decant waters from the dewatering barge would also release concentrations of contaminants that are elevated compared to background. Soluble and

3 i.e., contaminants bound to particles or dissolved in seawater. This distinction is important because it affects rates of dispersion and dilution, potentials for biological uptake, and ultimately the environmental fate of specific contaminants. Associations of chemical contaminants with particulate and dissolved phases depend on the specific solubilities and particle affinities (partitioning coefficients) of individual components. In general, most metals and chlorinated hydrocarbons contained in the shell mounds have strong affinities for particles, whereas petroleum hydrocarbons exhibit a wide range of compound-specific affinities for particles.

particulate contaminants associated with decant waters are expected to behave in similar fashion to those associated with dredging, although the decant plume would be most pronounced at the ocean surface.

Formation of an Oil Slick or Sheen on the Water Surface

Losses from the bucket dredge of materials containing free product, as well as from discharges of decant water containing oil may generate an oil slick or sheen on the water surface near the dredge. The appearance of the surface slick is expected to be similar to those associated with some active oil seeps in the Channel. The presence of a surface slick would decrease light penetration and gas- (e.g., oxygen-) exchange locally. Rapid losses to the atmosphere of volatile aromatic hydrocarbons would minimize the potential for toxicity to aquatic organisms. The spatial extent and persistence of the slicks would depend on weather and sea conditions. Under calm conditions, a surface slick is expected to persist for a relatively greater period of time, whereas strong winds with wind-induced surface turbulence (e.g., wind chop) would rapidly disperse the surface slick. Although the oil slick would not significantly degrade water quality, formation of an oil sheen would violate CDFG Office of Spill Prevention and Response (OSPR) and US Coast Guard (USCG) regulations.

Potential Exceedances of Water Quality Standards or Objectives

Maximum water column concentrations of chemical contaminants associated with sediment resuspension and bucket leaks can be estimated and compared to the instantaneous and average water quality criteria contained in the California Ocean Plan and USEPA water quality criteria (see Tables 3.2-7a through 3.2-7d). The water column concentrations are estimated using the concentrations measured in the mound core samples (AMEC 2002), and assuming all contaminants are associated with the particulate phase with worst-case suspended solids concentrations of 300 mg/L near the dredging site and 100 mg/L at a distance of 330 ft (100 m) from the dredging site. Because changes to water quality conditions from PA1 would be temporary and non-recurring, comparisons of estimated concentrations to chronic toxicity and human health values are considered less relevant than comparisons to instantaneous and acute toxicity criteria.

Although these criteria typically are not applied as limits for dredging projects (i.e., for dredging permits), they can be used as guidelines for determining whether or not water quality impacts associated with dredging operations may be significant and if additional precautions or alternate dredging measures are appropriate for reducing the magnitude of suspended solids concentrations in the plume. These comparisons indicate that concentrations of some metals, especially copper, chromium, and zinc, PCBs, and, at the Hazel shell mound site only, PAHs, may be expected to exceed Ocean Plan and/or USEPA acute toxicity values in the immediate vicinity of the dredge site. At a distance of 330 ft (100 m) from the dredging site, PCB concentrations may exceed the Ocean Plan limit at the Hilda, Hope, and Hazel shell mound sites, and chromium, copper, and PAHs may exceed the guidelines at the Hazel shell mound site only.

Table 3.2-7a. Estimated Water Column Concentrations of Contaminants Associated with Dredging Hope Shell Mound Sediments

Contaminant	HOPE						
	Composite Core Conc. (µg/g)	*Water Conc. At Dredge Site (µg/L)*	*Water Conc. 100 meters from Dredge Site (µg/L)*	*Ocean Plan Water Quality Criteria (µg/L)*[a]	*EPA WQ Criteria*		
					Saltwater Acute (µg/L)	*Saltwater Chronic (µg/L)*	*Human Health (µg/L)*
Antimony	ND	0	0	1200*	-	-	4300
Arsenic	3.23	0.97	0.32	32/80	69	36	0.14
Beryllium	ND	0	0	0.33*	-	-	-
Cadmium	ND	0	0	4/10	43	93	-
Chromium	49	15	4.9	8/20[b]	1100	50	-
Copper	16.6	5.0	1.7	12/30	2.9	2.9	-
Mercury	0.086	0.026	0.0086	0.16/0.4	2.1	0.025	0.15
Lead	28.6	8.6	2.9	8/20	140	5.6	-
Nickel	15.5	4.6	1.6	20/50	75	8.3	3800
Selenium	ND	0	0	60/150	300	71	-
Silver	ND	0	0	2.8/7	2.3	-	-
Thallium	ND	0	0	2*	2130	-	63
Zinc	493	148	49	80/200	95	86	-
Ammonia	15	4.5	1.5	2400/6000	-	-	-
PAHs	0.15	0.045	0.015	0.088*	300	-	0.0311
DDT	ND	0	0	0.00017*	0.13	0.001	0.00059
PCB	0.40	0.12	0.04	0.000019*	10	0.03	0.000079

Note: Water column concentrations estimated assuming TSS concentrations of 300 mg/L and 100 mg/L at the dredge site and 330 ft (100 m) from the dredge site, respectively, and that contaminants are associated entirely with the particulate fraction (i.e., attached to suspended solids).

a WQ criteria based on daily maximum/instantaneous maximum;

* water quality criteria for 30-day average.

b criteria are for hexavalent chromium; discharger may meet this objective with total chromium.

Table 3.2-7b. Estimated Water Column Concentrations of Contaminants Associated with Dredging Hazel Shell Mound Sediments

Contaminant	HAZEL						
	Composite Core Conc. (µg/g)	*Water Conc. At Dredge Site (µg/L)*	*Water Conc. 100 meters from Dredge Site (µg/L)*	*Ocean Plan Water Quality Criteria (µg/L)*[a]	*EPA WQ Criteria*		
					Saltwater Acute (µg/L)	*Saltwater Chronic (µg/L)*	*Human Health (µg/L)*
Antimony	ND	0	0	1200*	-	-	4300
Arsenic	7.32	2.2	0.73	32/80	69	36	0.14
Beryllium	ND	0	0	0.33*	-	-	-
Cadmium	2.39	0.72	0.24	4/10	43	93	-
Chromium	82.6	25	8.3	8/20[b]	1100	50	-
Copper	33.2	9.7	3.3	12/30	2.9	2.9	-
Mercury	0.074	0.022	0.007	0.16/0.4	2.1	0.025	0.15
Lead	95.2	29	9.5	8/20	140	5.6	-
Nickel	63.3	19	6.3	20/50	75	8.3	3800
Selenium	1.65	0.50	0.16	60/150	300	71	-
Silver	ND	0	0	2.8/7	2.3	-	-
Thallium	ND	0	0	2*	2130	-	63
Zinc	377	113	38	80/200	95	86	-
Ammonia	54	16	5.4	2400/6000	-	-	-
PAHs	1.6	0.48	0.16	0.088*	300	-	0.0311
DDT	ND	0	0	0.00017*	0.13	0.001	0.00059
PCB	0.40	0.12	0.04	0.000019*	10	0.03	0.000079

Note: Water column concentrations estimated assuming TSS concentrations of 300 mg/L and 100 mg/L at the dredge site and 330 ft (100 m) from the dredge site, respectively, and that contaminants are associated entirely with the particulate fraction.

a WQ criteria based on daily maximum/instantaneous maximum;

* water quality criteria for 30-day average.

b criteria are for hexavalent chromium; discharger may meet this objective with total chromium.

Table 3.2-7c. Estimated Water Column Concentrations of Contaminants Associated with Dredging Heidi Shell Mound Sediments

Contaminant	HEIDI						
	Composite Core Conc. (µg/g)	*Water Conc. At Dredge Site (µg/L)*	*Water Conc. 100 meters from Dredge Site (µg/L)*	*Ocean Plan Water Quality Criteria (µg/L)*[a]	*EPA WQ Criteria*		
					Saltwater Acute (µg/L)	*Saltwater Chronic (µg/L)*	*Human Health (µg/L)*
Antimony	ND	0	0	1200*	-	-	4300
Arsenic	2.93	0.88	0.29	32/80	69	36	0.14
Beryllium	ND	0	0	0.33*	-	-	-
Cadmium	ND	0	0	4/10	43	93	-
Chromium	67.6	20	6.8	8/20[b]	1100	50	-
Copper	10.4	3.1	1.0	12/30	2.9	2.9	-
Mercury	0.05	0.015	0.005	0.16/0.4	2.1	0.025	0.15
Lead	12.6	3.8	1.3	8/20	140	5.6	-
Nickel	16.7	5.0	1.7	20/50	75	8.3	3800
Selenium	ND	0	0	60/150	300	71	-
Silver	ND	0	0	2.8/7	2.3	-	-
Thallium	ND	0	0	2*	2130	-	63
Zinc	372	112	37	80/200	95	86	-
Ammonia	41	12	4.1	2400/6000	-	-	-
PAHs	0.15	0.045	0.015	0.088*	300	-	0.0311
DDT	ND	0	0	0.00017*	0.13	0.001	0.00059
PCB	ND	0	0	0.000019*	10	0.03	0.000079

Note: Water column concentrations estimated assuming TSS concentrations of 300 mg/L and 100 mg/L at the dredge site and 330 ft (100 m) from the dredge site, respectively, and that contaminants are associated entirely with the particulate fraction.

a WQ criteria based on daily maximum/instantaneous maximum;

* water quality criteria for 30-day average.

b criteria are for hexavalent chromium; discharger may meet this objective with total chromium.

Table 3.2-7d. Estimated Water Column Concentrations of Contaminants Associated with Dredging Hilda Shell Mound Sediments

Contaminant	HILDA						
	Composite Core Conc. (µg/g)	*Water Conc. At Dredge Site (µg/L)*	*Water Conc. 100 meters from Dredge Site (µg/L)*	*Ocean Plan Water Quality Criteria (µg/L)*[a]	*EPA WQ Criteria*		
					Saltwater Acute (µg/L)	*Saltwater Chronic (µg/L)*	*Human Health (µg/L)*
Antimony	ND	0	0	1200*	-	-	4300
Arsenic	4.73	1.42	0.47	32/80	69	36	0.14
Beryllium	ND	0	0	0.33*	-	-	-
Cadmium	ND	0	0	4/10	43	93	-
Chromium	56.5	17.0	5.65	8/20[b]	1100	50	-
Copper	12.9	3.87	1.29	12/30	2.9	2.9	-
Mercury	0.033	0.0099	0.0033	0.16/0.4	2.1	0.025	0.15
Lead	14.2	4.26	1.42	8/20	140	5.6	-
Nickel	30.3	9.09	3.03	20/50	75	8.3	3800
Selenium	1.91	0.57	0.19	60/150	300	71	-
Silver	ND	0	0	2.8/7	2.3	-	-
Thallium	ND	0	0	2*	2130	-	63
Zinc	468	140	47	80/200	95	86	-
Ammonia	39	12	3.9	2400/6000	-	-	-
PAHs	0.15	0.045	0.015	0.088*	300	-	0.0311
DDT	ND	0	0	0.00017*	0.13	0.001	0.00059
PCB	0.21	0.063	0.021	0.000019*	10	0.03	0.000079

Note: Water column concentrations estimated assuming TSS concentrations of 300 mg/L and 100 mg/L at the dredge site and 330 ft (100 m) from the dredge site, respectively, and that contaminants are associated entirely with the particulate fraction.

[a] WQ criteria based on daily maximum/instantaneous maximum

* Water quality criteria for 30-day average

[b] Criteria are for hexavalent chromium; discharger may meet this objective with total chromium.

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de Wit (2001) evaluated dissolved phase contaminants associated with shell mound materials by mixing portions of sediment cores with seawater and filtering the aqueous phase through filters with a 0.45-micron pore size. The elutriate (aqueous) phase of the three shell mound strata contained elevated concentrations of barium, chromium, zinc, and total PAHs compared to those for reference sediments. Maximum concentrations of these contaminants in the shell mound elutriate samples were 360 µg/L, 37.9 µg/L, 84 µg/L, and 1.2 µg/L, respectively, and concentrations of chromium, zinc, and PAHs exceeded the respective 30-day average criteria in Table B of the Ocean Plan. Oil and grease and TRPH concentrations in the elutriate samples for the top and middle strata of the shell mounds were also considerably higher than those of the reference sediment elutriate samples, whereas PCBs were not detected in the shell mound elutriate samples.

Despite the elevated contaminant concentrations in the shell mound elutriate samples, results from sediment testing of the shell mound materials did not indicate any significant toxicity to marine test species in suspended phase bioassays (AMEC 2002). Consequently, it may be concluded that the dissolved fraction of the shell mound components in a turbidity/suspended sediment plume would not be expected to significantly degrade water quality. This contrasts with the significant acute toxicity observed in the solid phase bioassay tests, and contaminant uptake in bioaccumulation tests, that indicated the limiting permissible concentrations (LPC) for benthic effects due to dredged material disposal at an ocean dredged material disposal site were exceeded. Because PA1 would remove the shell mounds, benthic effects would relate only to residual materials (discussed below under Impact WQ-3).

SUMMARY OF IMPACTS

In summary, releases of contaminants that exceed federal and State standards during dredging, loading, and dewatering, although a significant impact, would be temporary, non-recurring, and likely to occur only within a limited portion (i.e., depth range) of the water column and within an approved mixing zone, as defined by the WDR and dredging permit. The WDR for the decant water discharge may contain additional requirements for documenting that the quality of the discharge meets specific limits for water quality parameters at the boundary or beyond the mixing zone, as well as monitoring and reporting requirements. Implementation of the mitigation measures identified below would ensure that impacts to water quality associated with turbidity plumes, reduced light transmittance, and sheens remain localized and temporary. As a result, such impacts associated with PA1 are considered significant but mitigable to levels of less than significant (Class II).

Impacts: Final Site Smoothing

Final site smoothing would follow the dredging operation at each of the shell mounds to remove residual solids debris that was not collected with the bucket dredge. Site smoothing would require an additional 2 to 3 days per mound, or 8 to 12 days total. Site smoothing using a gorilla net will resuspend bottom sediments and create a turbidity plume in near-bottom waters. During the presence of a natural water-column density

stratification, plumes are not expected to rise into the near-surface layers and, therefore, would not visible at the water surface. Some of the sediments in the plume may comprise residual shell mound materials that were not removed by dredging. As discussed above, based on the results of the suspended phase bioassay testing of the shell mound sediments (AMEC 2002), the turbidity plume is not expected to cause acute toxicity to aquatic organisms exposed to the plume. Similar to dredging operations, bottom sediments suspended during site smoothing would settle to the seafloor within a few hours following the smoothing operations and within several hundred feet of the site. Therefore, potential impacts associated with final site smoothing would be similar to dredging impacts (Class II).

Impacts: Hazel Caissons Removal

Caisson removal operations, which pertain only to the Hazel shell mound, would occur after most or all of the Hazel shell mound materials have been removed. The use of explosives and equipment to cut, lift, and recover the caissons would result in localized resuspension of bottom sediments and residual shell mound materials, with associated increases in near-bottom suspended sediment concentrations and turbidity levels. Turbidity and suspended sediment plumes associated with removal of remaining platform structures would be temporary and generally restricted to near-bottom waters in the immediate vicinity of the platform structures. Some of these disturbed sediments may contain elevated contaminant concentrations associated with residual shell mound materials that were not removed during dredging. However, the amount of sediment disturbed by these operations, and the potential for impacts to water or sediment quality, would be small, and sediments disturbed by caisson removal activities would settle rapidly to the bottom. Based on the results of sediment testing (AMEC 2002), exposures to suspended particulates would not cause significant toxicity to marine organisms. Therefore, this impact would be less than significant (Class III).

Impacts: Anchoring

Anchoring dredges and barges near the shell mounds would also resuspend bottom sediments, but the extent of sediment resuspension would be substantially less than that caused by the dredging and final site smoothing activities. However, unlike dredging operations, sediments suspended by anchoring are expected to remain in the lower portions of the water column and not affect surface or near-surface waters. Bottom sediments suspended by anchoring operations are expected to settle rapidly and near (e.g., within 1,600 ft [500 m]) their origin (MMS 2001). These impacts are considered less than significant (Class III), and no mitigation measures are necessary. The significance of anchoring impacts is greater when the objective is to leave the shell mounds in place (Program Alternatives 3-6), since anchors would need to be set so as not to disturb, and release contaminants from, the mounds. Potential impacts from anchoring on marine biota are discussed in Section 3.4.

MITIGATION MEASURES FOR IMPACT WQ-2

WQ-2a *The Applicant shall use an enclosed (environmental) bucket dredge and dredging practices for contaminated sediments that minimize: (1) resuspension of bottom sediments, (2) leakage/spillage of dredged solids and entrained water through bucket seals and vents during retrieval, and (3) overflow from barges. Such practices shall include imposing limits on filling of barges to prevent overflow of dredged material. If the presence of appreciable amounts of debris or shell hash prevents complete closure of the dredge bucket, resulting in unacceptably high spillage volumes and suspended sediment concentrations in surface plumes, the Applicant will suspend dredging operations and physically remove the debris from the shell mound or incorporate alternate dredging methods that minimize losses of shell mound materials to surface waters. Examples of alternate methods include diver-deployed suction devices or airlifts. To minimize potential for accidental spills, dredging operations shall be discontinued when local winds exceed 25 knots and seas exceed 5 ft.*

WQ-2b *Sixty (60) days prior to commencement of dredging, the Applicant shall submit for approval by the California State Lands Commission and California Coastal Commission, and in consultation with the Central Coast Regional Water Quality Control Board, a design and operating procedures for a filtration system to be installed on the dewatering barge to reduce suspended solids concentrations and petroleum hydrocarbons in the decant waters. The Applicant shall install the filtration system on the barge and ensure that it is implemented consistent with the approved procedures and achieves the stated removal efficiencies for solids and oil.*

WQ-2c *Sixty (60) days prior to commencement of dredging, the Applicant shall submit for approval by the California State Lands Commission and California Coastal Commission, and in consultation with the Central Coast Regional Water Quality Control Board, a Plan for implementing additional Best Management Practices (BMPs) to reduce suspended sediment levels in site waters in the event that water quality monitoring (e.g., suspended sediment concentrations) near the dewatering barge indicates that Total Suspended Solids (TSS) concentrations exceed 100 mg/L at a distance of 330 ft (100 m) from the barge.*

WQ-2d *If the Waste Discharge Requirement (WDR) for the decant water discharge specifies the spatial limit of the initial mixing zone, the Applicant shall document that the quality of the discharge meets specific limits for water quality parameters at the boundary of or beyond the mixing zone, in addition to any other monitoring and reporting requirements.*

WQ-2e *During dredging and final site smoothing, the Applicant shall provide an on-site response team with equipment (e.g., booms and skimmers) capable of containing and removing an oil slick formed near the shell mound sites.*

Containment booms should conform to recommendations in ASTM F-1523-94 (2001: Standard Guide for Selection of Booms in Accordance with Water Classifications). If initial dredging operations result in the formation of surface oil slicks, dredging will be limited to daylight hours.

RESIDUAL IMPACTS

Use of the enclosed (environmental) bucket dredge and the implementation of other measures (MM WQ-2a through MM WQ-2e) would minimize turbidity and the dispersal of contaminants from the dredging site.

Where appropriate, effective deployment of a containment boom can ensure that oil slicks associated with the dredging and smoothing operations do not degrade water quality or threaten wildlife. As wind and wave conditions increase, the effectiveness of containment booms generally is expected to decrease, although the specific limits for suitable working conditions can vary depending on the individual boom design. Under sea conditions in which containment booms become ineffective, the natural turbulence will disperse small slicks that could form as a result of shell mound removal operations. Impacts to water quality from dispersed oils would be less than significant and indistinguishable from those associated with natural oil seeps in the region.

Silt curtains have been used effectively in protected water bodies to minimize dispersion of turbidity plumes created by dredging operations. However, in open coastal waters, with surface currents greater than about 1 knot and wave heights greater than 3 feet, the effectiveness of silt curtains would be limited. Under these conditions, natural turbulence will rapidly disperse a surface plume, and minimize the potential for water and sediment quality impacts associated with turbidity plumes, thereby obviating the use of a silt curtain.

With the implementation of the mitigation measures specified above, impacts to water and sediment quality associated with dredging, dewatering, and final site smoothing are less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA1	**WQ-3**	Residual shell mound materials (i.e., any material remaining after dredging and smoothing operations have been completed) have the potential to cause acute toxicity and/or contaminant bioaccumulation.	Shell mound sites. This impact could affect sediment quality within the original footprints of the mounds.	II

Impacts: Residual Materials

Residual shell mound materials that are redeposited following dredging and not removed during final smoothing represent the potential for acute toxicity and contaminant bioaccumulation. As discussed above, particle-bound contaminants

associated with materials resuspended or spilled during dredging and smoothing are expected to be dispersed by local currents and eventually settle and accumulate on the bottom. Larger cutting particles would settle close to the original mound footprint, whereas the smaller diameter, drilling mud particles would be dispersed over a relatively larger area. Consequently, the area of the footprint associated with settling particles could be considerably larger after dredging and smoothing than the original footprint of the shell mound, although the thickness of this layer of settled particles would be very small.

The area affected by settling particles can be estimated from the settling rate of particles and the mean current velocity. Assuming a maximum water depth of 130 ft (40 m), current velocity of 0.3 ft/s (10 cm/s), and particle settling rate of 0.0046 ft/s (0.14 cm/s) (for coarse silt-sized particles), shell mound particles would settle within 2 miles (3 km) of the site, primarily at the same depth of the mound up- and down-coast from the site. Larger particles, such as sand and gravel-sized cuttings would settle closer to the original mound site. Similarly, sediments suspended from the bottom during smoothing would settle closer to their origin than similar-sized material spilled at the surface. The larger particles and residual debris will be removed during final site smoothing. Consequently, the amount of residual shell mound particles, and associated contaminants, accumulating within a particular area of the seafloor is expected to be small, and accumulation of residual materials is not expected to cause substantial changes to the texture (grain size) or quality of the adjacent bottom sediments. Subsequent deposition and accumulation of natural sediments, and mixing of residual shell mound materials with existing sediments, would progressively reduce the extent of any changes in sediment texture or sediment quality related to settling shell mound materials.

Results from testing the shell mound sediments (AMEC 2002) can be used to characterize the potential for acute toxicity and contaminant bioaccumulation in aquatic organisms exposed to the shell mound residues. The sediment testing results: (1) indicated the potential for significant acute toxicity to bottom-dwelling marine organisms exposed to undiluted, solid phase materials (analogous to the layer of deposited shell mound material), and significant bioaccumulation of some metals, particularly barium, and PAHs; (2) did not indicate significant PCB bioaccumulation in test organisms; and (3) demonstrated that the suspended particulate phase of the materials was not toxic and dilution would minimize exposure times to pelagic or mid-water organisms. During dredging, the more soluble and acutely toxic contaminants, such as the volatile organic and lower molecular weight PAHs, would likely be released to overlying waters. Releases of these components from the shell mound solids to ambient waters, as well as mixing and dilution with existing bottom sediments, would reduce the toxicity of the residual solids. Therefore, the potential for acute toxicity may be localized and temporary. Similarly, losses of soluble PAHs and dilution would reduce the potential for significant bioaccumulation of these shell mound-related contaminants. While accumulations of barium, chromium, and, to a lesser extent, cadmium, copper, and lead have been observed previously in laboratory investigations of metal bioaccumulation by marine organisms exposed to drilling fluids and drilling fluid components, the magnitude of accumulation was small (Neff 1987).

In sum, because the sediment testing results demonstrated that the suspended particulate phase of the materials was not toxic and dilution would minimize exposure times to pelagic or mid-water organisms, any toxicity or contaminant uptake related to dispersal of shell mound materials would most likely occur in bottom-dwelling organisms. If appreciable amounts of shell mound materials remain, this could pose a significant impact that could be mitigated to a level of less than significant (Class II) with implementation of MM WQ-3a.

MITIGATION MEASURES FOR IMPACT WQ-3

WQ-3a *Within 45 days of completion of site smoothing, the Applicant shall conduct post-clearance surveys, using a remote video system to verify removal of all large shell mound debris, and shall collect and analyze bottom sediments to verify that background contaminant concentrations are achieved. A minimum of four sediment samples (grab samples) shall be collected within the footprint of the individual shell mounds, and all samples shall be analyzed separately for chemical contaminants. Contaminant concentrations within all samples shall not be statistically higher than corresponding background values (from a location[s] removed from the shell mounds and other possible contaminant sources at a comparable bottom depth and with comparable sediment texture). Any materials that exceed background concentrations shall be removed within 90 days, and the area shall be retested to confirm that all residual shell mound materials have been removed. Within 120 days, the Applicant shall submit a report to the California State Lands Commission and California Coastal Commission containing the results from the post-clearance surveys as documentation that background contaminant concentrations exist within the footprints of the 4H shell mounds.*

RESIDUAL IMPACTS

Implementation of MM WQ-3a will ensure that contaminant concentrations in sediments and potential impacts associated with residual shell mounds materials would be less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA1	**WQ-4**	Significant toxicity and contaminant bioaccumulation would result from:		
		• disposal of dredged shell mound sediments at LA-2 or a major spill of barge contents at a single location; or	LA-2 dredged material disposal site or enroute or at POLB	I
		• spills of dredged materials during transport to, or unloading at, an onshore transfer point.	Enroute or at POLB	II

Impacts: Disposal at LA-2

Results from sediment testing (AMEC 2002) indicated that the shell mound materials are unsuitable for ocean disposal because they do not meet the LPC for sediment

quality (benthic effects and bioaccumulation). Therefore, potential impacts to marine water and sediment quality at the LA-2 disposal site are considered significant. Because there is no feasible mitigation that would remove contaminants from the materials prior to disposal, Impact WQ-4 is not mitigable (Class I).

Impacts: Leaks/Spillage During Transport/Offloading

Impacts to water and sediment quality from PA1 could occur if materials were spilled or leaked during transport and unloading from barges for onshore transport. Accidental releases or spills of sediments from the barge during transport would cause adverse impacts to marine water and sediment quality, including formation of a turbidity plume, with elevated concentrations of suspended sediments and any particle-associated contaminants, and deposition and accumulation of contaminated sediments on the seafloor. The magnitude and areal extent of water and sediment quality impacts would depend on the leakage rate of materials from the barge; similarly, deposition and accumulation of sediments leaked or spilled from the barge would depend on the amount of materials spilled. If the major portion of the barge contents were released at a single location, water and sediment quality impacts would be comparable (significant and unmitigable, Class I) to those associated with disposal of shell mound materials at the LA-2 disposal site.

Spills or leaks of dredged sediments may also occur when materials are off-loaded at the POLB. Spills into the Port would create a turbidity plume with elevated concentrations of suspended sediments and particle-associated contaminants. Turbidity and suspended sediment plumes, associated with a large spill within the Port, may be more persistent than those in open coastal waters due to restricted water movement and dilution. Nevertheless, based on sediment testing results, the plume would not be expected to cause significant toxicity to marine organisms. Additionally, sediments would be expected to settle and accumulate in the immediate vicinity of the transfer site because water movement and the potential for dispersion of particulates typically are reduced inside commercial ports and harbors. If substantial amounts of materials settled to the bottom within the Port, some localized potential for acute toxicity and/or bioaccumulation of contaminants exists. The magnitude and areal extent of related impacts to water and sediment quality within the Port would depend, in part, on the amount of material spilled. In most cases, the amount of material leaked into Port waters is expected to be small, and related impacts to water and sediment quality would be less than significant. Although unlikely, spills of large volumes of material could result in localized but significant impacts to water or sediment quality (Class II).

The potential for spills or leaks of dredged materials from barges can be minimized by filling below capacity as specified in MM WQ-2a and by keeping to approved vessel traffic corridors to minimize the risks of collisions. Monitoring the draft of the barge during transit is also standard practice to verify that losses or leaks are non-existent or negligible. Mitigation measures to minimize the potential for significant impacts associated with transporting shell mound materials are described in Section 3.4 (MM MB-4a and 4b).

Impacts: Upland Disposal

Upland disposal of dredged sediments would occur at a designated, permitted disposal site(s) with appropriate facilities for retaining landfilled materials and preventing offsite migration of contaminants (see Section 3.8). Consequently, upland disposal would not affect marine water or sediment quality, toxicity or bioaccumulation of contaminants in aquatic biota, or declines in wildlife habitat, and impacts to marine water and sediment quality from upland disposal would be less than significant (Class III).

MITIGATION MEASURES FOR IMPACT WQ-4

There is no feasible mitigation that would remove contaminants from the materials prior to disposal at the LA-2 dredged material disposal site.

MMs WQ-2a, MB-4a and **MB-4b** would apply for spills/leakage during transport or offloading.

RESIDUAL IMPACTS

Since mitigation is not feasible for disposal at LA-2, the residual impact remains significant (Class I). Implementation of MMs WQ-2a, MB-4a and MB-4 would help to ensure that impacts to water and sediment quality associated with potential spills or leaks during transport of materials remain less than significant (Class III).

3.2.4.2 Program Alternative 2 (PA2): Leveling and Spreading of Shell Mounds with Caissons Removal and Disposal

PA2 would use a standard clamshell dredge to spread most of the shell mound materials on the seafloor adjacent to the present shell mound footprints, within a 600 to 2,000 ft (180 to 600 m) diameter area around each shell mound site. Spreading would remove the existing mounds but create a layer approximately 1 foot (0.3 m) thick of shell mound material over the natural sediments within this area. Large debris associated with the shell mounds and the remnant caissons at the Hazel site would be removed using methods previously described, and site smoothing would be accomplished with a “gorilla net”, similar to PA1.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA2	**WQ-5**	Spreading-related operations will disturb and resuspend shell mound materials resulting in: (1) elevated levels of suspended solids and increased turbidity (reduced water clarity/light transmittance), (2) release of soluble contaminants, especially lower molecular weight aromatic hydrocarbons and free product (petroleum) to waters above the shell mounds; (3) formation of an oil slick or sheen on the water surface from releases of petroleum hydrocarbons contained in the mounds; and (4) potential exceedances of water quality standards or objectives. Specific activities include:	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of each of the shell mound sites, as well as sediment quality beyond the present footprints of the mounds.	
		• Spreading, leveling, and smoothing;		II
		• Hazel caissons removal (post-spreading);		III
		• Anchoring.		III

Impacts: Spreading, Leveling, and Smoothing

SUSPENDED SOLIDS/TURBIDITY EFFECTS ON WATER CLARITY/LIGHT TRANSMITTANCE

The spread-in-place alternative would suspend shell mound materials into near-bottom waters and create a turbidity plume with elevated suspended sediment and contaminant concentrations. Because the spreading and smoothing operations would not require dredging, recovery, or dewatering of the shell mound materials, PA2 would not involve any potential discharges or spills of dredged materials or decant wastes to surface waters. Turbidity plumes are expected to persist for the duration of the spreading and smoothing operations at each mound. Based on information provided in Section 2.4.4, spreading is estimated to last from 3 to 4 days per site, assuming 24-hour operations. Smoothing operations would require an additional 2 to 3 days at each of the mound sites.

Compared with PA1, spreading and leveling operations would be expected to release relatively greater quantities of suspended solids and is more disruptive than dredging with an enclosed bucket dredge. Natural density layering of seawater is expected to provide a barrier that prevents or minimizes the potential for the near-bottom plume (other than buoyant oil-related materials) to mix into surface waters. Since surface-deployed dredging curtains or booms would not be effective for restricting the horizontal dispersion of a plume of suspended sediments in near-bottom waters at the depths of

the 4H shell mounds, it would not be possible to restrict the spatial extent or reduce the concentrations of mound-related contaminants. However, suspended sediment/turbidity plumes created during spreading and smoothing are expected to remain in the near-bottom water layers, and they would not be visible on the surface. Following completion of the spreading, leveling, and smoothing operations, the suspended sediment/turbidity plume is also expected to disperse within hours due to mixing, dilution, and settling of suspended solids.

RELEASE OF SOLUBLE CONTAMINANTS/POTENTIAL EXCEEDANCES OF WATER QUALITY CRITERIA

Similar to dredging operations discussed for PA1, shell mound spreading operations for PA2 could release particulate-phase contaminants to the water column. Compared with PA1, spreading and leveling operations would be expected to release relatively greater quantities of soluble contaminants and petroleum hydrocarbons because the spreading method would not retain or remove any solids and is more disruptive than dredging with an enclosed bucket dredge. However, because the spreading and smoothing operations would not require dredging, recovery, or dewatering of the shell mound materials, PA2 would not involve any potential discharges or spills of dredged materials or decant wastes to surface waters.

Potential impacts would be more extensive than those associated with dredging/ removal alternatives because the entire mass of contaminants associated with the mounds is potentially subject to dispersal. The fate of various inorganic and organic contaminants would vary depending on their affinities for suspended particles and solubility in seawater. In general, the soluble fraction, including the lower molecular weight aromatic compounds, will be diluted and disperse. The particulate fraction, including most metals and higher molecular weight hydrocarbons, would remain with the solids portion of the mound that is spread over the bottom or settle rapidly to the bottom within about 0.6 miles (1 km) of the original mound footprints. Thus, the initial mound spreading would primarily affect concentrations of soluble hydrocarbons in waters above the mound. Concentrations of both particulate and dissolved contaminants would also decline with time due to mixing, dilution, and chemical/biological degradation. Similar to the removal alternative, concentrations of some contaminants associated with suspended particles may exceed water quality standards. Concentrations of some metals, PCBs, and PAHs could exceed some water quality limits and standards for acute or chronic toxicity in the general vicinity of the shell mound sites. Suspended shell mound solids also may cause temporary and localized reductions in DO concentrations. However, because these conditions would be temporary, and site waters are well-oxygenated, this action would not substantially degrade water quality or cause conditions in the water column that would adversely affect aquatic organisms. This would occur only in near-bottom waters and, following completion of spreading, concentrations would return quickly to background values as the suspended solids settled to the bottom.

FORMATION OF AN OIL SLICK OR SHEEN

The size and extent of surface oil slicks/sheen formed as a result of in-place spreading of the mounds would depend on the volume of oil released, the amount of turbulence available to mix and disperse the slick, and rates of oil weathering. The volumes of oil cannot be estimated accurately because the oil residues are not distributed homogeneously in the shell mounds, and extrapolations from the sediment coring observations to the entire mounds would involve large uncertainties.

IMPACTS SUMMARY

In summary, impacts associated with spreading and leveling operations are expected to be short-term (approximately 5 to 7 days per site) and generally confined to near-bottom waters within about one to several miles of the new (i.e., spreading) footprint. The residual water quality impacts from the near-bottom suspended sediment plumes would be less than significant (Class III). No decant water discharges would be required. Implementation of the mitigation measures identified below would ensure that impacts to water quality associated with oil sheens or slicks remain localized and temporary. As a result, such impacts associated with PA2 are considered significant but mitigable to levels of less than significant (Class II).

Impacts: Caisson Removal and Anchoring

Impacts to marine water and sediment quality associated with caisson removal, which would apply only at the Hazel site, and anchoring for PA2 would be comparable to those associated with PA1 (see Impact WQ-2). These impacts would consist of localized and temporary resuspension of bottom sediments and residual shell mound materials, with associated increases in near-bottom suspended sediment concentrations and turbidity levels at the Hazel site only. Some of these disturbed sediments may contain elevated contaminant concentrations. Disturbed bottom sediments would settle rapidly to the bottom. However, the amount of sediment disturbed by these operations, and the potential for impacts to water or sediment quality, would be small, temporary, and generally restricted to near-bottom waters in the immediate vicinity of the site. Based on the results of sediment testing (AMEC 2002), short-term exposures to the suspended particles would not cause significant toxicity to marine organisms. Therefore, this impact would be less than significant (Class III), and no mitigation is proposed.

MITIGATION MEASURES FOR IMPACT WQ-5

WQ-5a *The Applicant shall maintain a spill response vessel, equipment, and personnel to retain and clean surface slicks created during site spreading and smoothing operations. Containment booms should conform to recommendations in ASTM F-1523-94 (2001: Standard Guide for Selection of Booms in Accordance with Water Classifications). If initial leveling and spreading operations result in the formation of surface oil slicks, spreading will be limited to daylight hours.*

RESIDUAL IMPACT(S)

MM WQ-5a is expected to minimize impacts associated with a surface slick of oil released from the shell mounds (as well as potential fouling of wildlife; see Section 3.4). The use of oil spill containment and cleanup equipment is expected to be effective only under favorable weather conditions. Under strong winds and large sea conditions, the effectiveness of this equipment is limited, but natural turbulence would disperse a small slick, and residual impacts to water quality would be less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA2	**WQ-6**	Chronic toxicity and contaminant bioaccumulation could occur in areas where spreading and mixing with native sediments are inadequate to reduce contaminant concentrations to the extent they are no longer deleterious.	Offshore Santa Barbara County. The impact could affect sediment quality within several hundred feet of the present shell mound sites.	I

Impacts

The results of solid phase bioassay sediment tests conducted on the shell mound materials (AMEC 2002) indicated that the materials do not meet ocean discharge criteria (limiting permissible concentration for benthic effects and bioaccumulation). Redistributing the material onto the natural seafloor initially would expose existing infauna and epifauna to potential toxic effects demonstrated in the aforementioned testing. The process of physically redistributing the mounds would release the more acutely toxic contaminants, such as the lower molecular weight aromatic hydrocarbons, to the overlying waters. Losses of these components would, in turn, progressively reduce the toxicity of the shell mound sediments. As a result, acute toxicity impacts would be relatively localized and short-term, although they would be of greater scale compared to what would occur during the dredging and transfer operations of PA1. Conversely, contaminants with greater affinities for sediments would remain associated with the residual shell mound materials spread on the seafloor, and this represents a longer-term risk for chronic toxicity and contaminant bioaccumulation in aquatic organisms. The implications of this are discussed in great detail below, followed by a summary and conclusions.

DETAILED ANALYSIS

The effects of oil platform drilling wastes (e.g., muds and cuttings) and oil residues on aquatic organisms have been well studied. In general, reviews of extensive data from exposure assessments (Neff 1987; NRC 1983) have concluded that most water-based drill muds used in OCS drilling operations have low acute and chronic toxicities to representative marine organisms. Two of the primary components of drill muds, barite and bentonite, are considered essentially inert with negligible potential for acute toxicity

to marine organisms (Neff, 1987). NRC (1983) identified diesel fuel and biocides as the most toxic constituents of drill muds. Although discharges of oil-based muds to the ocean presently are prohibited, a review of drilling logs for the 4H Platforms (O'Reilly 1998) noted that both water-based and oil-based muds were used, although oil-based muds were used infrequently. Previous studies have also identified chrome lignosulfonates and sodium hydroxide as moderately toxic components of drilling muds. Although no longer approved for use, chrome lignosulfonates were common drilling mud additives when the 4H Platform wells were drilled. Because chromium concentrations were elevated primarily in the middle layer at each of the shell mounds, it is likely that chrome or ferrochrome lignosulfonate was used at the 4H Platforms as a drilling mud additive. The toxicity of sodium hydroxide is attributable solely to elevated pH levels. Because seawater is a highly buffered system, sodium hydroxide released during the shell mound operations is not expected to appreciably alter the pH of the receiving waters or cause impacts to marine organisms.

Studies of sublethal or chronic effects from drill mud exposures have been conducted with more than 40 marine taxa. Many of the studies, using oil (diesel)-based or chrome lignosulfonate muds, observed sublethal responses at exposure levels only slightly lower than those causing acute toxicity, and chronic effects associated with the more toxic mud formulations were observed at concentrations as low as 10 to 100 parts per million (Neff, 1987). General categories of responses observed from these studies can be classified as biochemical/ physiological or behavioral. Based on the results of these studies, the chronic toxicity of drill muds appears to vary as a function of time and corresponding acute toxicity values, and the chronic lethal toxicity values generally are within an order of magnitude of the 96-hour lethal concentration (LC_{50}) values (Petrazuollo 1983).

Long-term studies have focused on two major primary types of responses. The first is the effect of drill muds on behavior, reproduction, growth/development, and physiological/biochemical conditions. Much of this information is from early studies using chromium or ferrochrome lignosulfonate muds or muds containing diesel additives. The other major area of focus has been metal accumulation in organism tissues. Laboratory studies on community recruitment and development of bottom-dwelling organisms have been performed using whole muds or barite mixed with sediments or applied in a layer over sediments. These experiments ranged from 8-10 weeks in length (Cantelmo et al. 1979; Tagatz et al. 1978; Tagatz and Tobia 1978). Polychaete worms exhibited the most significant changes in abundance related to concentrations of drill mud sediment mixtures and layered muds; similar sensitivity was noted as a result of exposure to barite. Coelenterate (e.g., anemones and corals) abundance was significantly reduced from exposure to both the mud mixture and the mud layer. Unlike the polycheate worms, however, the coelenterate reductions were not concentration-dependent. Arthropods (e.g., shrimp and crabs) reacted only to the drill mud layer over sediment. Molluscs (e.g., clams and mussels) did not appear to be significantly affected by the drilling fluid applications but were affected by a barite covering. Exposure to the barite sediment mixture increased abundance and density, while a barite layer over sediment reduced density and abundance of small nematode worms.

Drill muds and cutting are primary sources for several metals associated with drilling-related discharges. The potential for accumulation of metals in biota at levels that may become toxic to the organism or higher trophic levels are an issue of concern in the assessment of oil and gas impacts. Concentrations of metals required to produce physiological or behavioral changes in organisms vary widely and are determined by factors such as the physiochemical characteristics of the water and sediments, the biochemical form of the metal, the organism's size, physiological characteristics and feeding adaptations. Metals are accumulated at different rates and to different concentrations depending on the tissue or organ involved. Enrichment factors were generally low (<10), with the exception of barium and chromium with maximum enrichment factors of 300 and 36, respectively (Neff 1987).

Studies have shown that organisms tested have the ability to excrete some metals when removed from the exposure. In various tests, animals were exposed to drill fluids from 4 to 28 days, followed by a 1 to 14 day post-exposure period. Uptake and release of barium, chromium, lead, and strontium were monitored and showed a 40 to 90 percent decrease in excess metal in tissues during the post-exposure period. Longer exposure periods generally meant a slower rate of loss of the metal. In addition, release of the excess metal was slowed if uptake was through food rather than from solution. Jenkins et al. (1989) conducted studies of barium uptake in organisms exposed to drill muds from operations in central California. The results indicated uptake of barium by exposed organisms; however, the barium was present in tissue cells as discrete barium sulfate particles and not as constituent of the tissue matrix. Further, the organisms were capable of subsequently eliminating the ingested barium sulfate. Thus, although some evidence for metal bioaccumulation from drill mud exists, the magnitude of bioaccumulation is low (e.g., usually less than a factor of five; EPA 1999).

In general, responses of organisms to petroleum hydrocarbon exposures can occur at four levels of organization, biochemical or cellular, organismal, population, and community. All responses are not necessarily disruptive and do not necessarily result in impacts to the next level. Adaptive processes or tolerances are capable of countering exposures up to a threshold, at which point the ability of the organ, organism, or population is exceeded and an impact is expected (e.g., Capuzzo 1987).

Because oils and refined petroleum products are complex mixtures of many individual compounds, the toxicities and potential for biological effects are not expected to be uniform for different oil types. Differences among oils and petroleum products in toxicity are attributable to availability and persistence of aromatic compounds, while the relative toxicities of individual hydrocarbon compounds are related to their solubilities. Additionally, the acute and chronic toxicities of some petroleum can be enhanced by formation of oxidized products from photo-oxidation following exposures to natural sunlight. Acute toxicity of petroleum hydrocarbons also varies considerably among species, as well as developmental stages and routes of exposure.

Further, acute toxicity of hydrocarbons is not strictly dose dependent, but related to the bioavailability of toxic components and time of exposure (Capuzzo 1987). Toxic responses to hydrocarbon exposures are attributable to compounds binding to sites

within the cell and interfering with metabolic processes and/or metabolites binding to macromolecules and altering cellular or subcellular structure.

The long-term effects of petroleum to organisms are related to the persistence and bioavailability of specific hydrocarbons; abilities of organisms to metabolize, purge, or store hydrocarbons; the fate of metabolites; and interference of hydrocarbons with metabolic processes that may alter survival and reproduction. The potentials for bioaccumulation of hydrocarbons are complex, and dependent on biological availability as soluble or droplet forms in water, and/or as bioavailable fractions adsorbed to sediments or from food sources, solubility and partitioning behavior of individual compounds or complex mixtures, length of exposure, and the organism's capacities for metabolic transformations (Dauble et al. 1986). Bioaccumulation of volatile aromatic compounds (e.g., benzene and ethylbenzene) in tissues of marine organism to levels that represent a human health risk are not expected because these compounds have very low bioconcentration factors (i.e., affinities for uptake and accumulation by organisms). Long-term chronic stress is related to the more persistent components, particularly alkylated phenanthrenes and dibenzothiophenes.

The balance between uptake pathways and elimination mechanisms will determine the extent and magnitude of bioaccumulation. Differences among individual species groups and life stages in their abilities to metabolize hydrocarbons will alter tendencies for accumulation and retention of hydrocarbons. Sublethal effects from hydrocarbon exposures may include impairment of feeding, growth, development, energetics, and recruitment, which, in turn, may alter population and community structures. Subcellular responses to chronic exposure may include changes in energy metabolism, alterations in cellular structure and function, and enhancement of chromosomal mutation. The presence of various morphological and developmental abnormalities have been described in organisms exposed to petroleum. The relationships between metabolite formation and subcellular (i.e., histopathological) damage in fish have been inferred but not established definitively.

Numerous studies indicate that low concentrations of petroleum hydrocarbons are readily absorbed by many marine organisms within a few hours of exposure (*cf*., Connell and Miller 1981). Absorption occurs through respiratory surfaces, the gastrointestinal tract, and external surfaces. Impacts from hydrocarbon exposure in the marine environment can occur in a variety of ways including direct lethal toxicity, direct coating, habitat disruption, tainting, physiological disruption, behavioral disruption, and bioaccumulation. Direct lethality from coating and habitat disruption is largely a consequence of short-term catastrophic oil spills.

The long-term contamination in the marine environment depends on the aqueous partitioning of hydrocarbon compounds, the organisms exposed, and the nature of the toxicity. Weathering and leaching processes change the chemical character of hydrocarbon contaminants dissolved in seawater or adsorbed to sediments. In this regard, the aromatic hydrocarbons are more soluble in sea water and exhibit greater toxic effects on marine biota than the saturated fraction (e.g., normal or cyclic alkanes). The alkane petroleum components that constitute much of non-aqueous phase liquids

are less toxic to marine organisms because of their lower solubility in seawater (Connell and Miller 1980). Dissolution and toxic effects are more pronounced at lower molecular weights and these constituents are often concentrated in the dissolved phase.

Sublethal effects in marine organisms can manifest themselves in many ways. Generally, they impair the ability of organisms to function effectively without causing direct mortality, although they can be indirectly lethal. Sublethal effects have been reported at soluble hydrocarbon concentrations down to 0.001 mg/L. These sublethal concentrations disrupt physiological activity. Chronic effects can extend from individual organisms and species through successive levels of biological interactions including those among marine communities and ecosystems. The latter effects are reflected in a greater susceptibility to predation, reduced ability to colonize, and overall shifts in species composition and diversity.

Tainting can occur when petroleum hydrocarbons enter edible fish, crustacean, and mollusk species. Acquisition of taint by fish and shellfish is rapid, in most cases occurring within 24 hours, as a result of very low concentrations in seawater (Connell and Miller 1981). Tainting from hydrocarbon compounds is primarily olfactory rather than taste and results from the presence of the volatile hydrocarbon compounds.

SUMMARY AND CONCLUSIONS

In summary, PA2 would disperse the shell mound materials and associated residual contaminants. Spreading the shell mounds is expected to cause significant toxicity and contaminant bioaccumulation in benthic (bottom-dwelling) organisms. Concentrations would be diluted as shell mound sediments mix with adjacent sediment. Therefore, some contaminants potentially could be bioavailable, and over a relatively long time frame, but presumably at lower concentrations than existing materials. Specific types and magnitudes of biological effects cannot be predicted reliably because the biological response can vary depending on a number of factors. Regardless, the sediment testing results (AMEC 2002) indicated potentials for significant benthic effects and bioaccumulation that exceed the ocean discharge criteria. Effects would be limited to a fairly narrow zone around the area of sediment dispersal. The magnitude of these impacts would be similar at each of the 4H shell mounds, with the exception that spreading/leveling of the Heidi shell mound would not affect PCB levels in bottom sediments (because PCBs were not detected in the Heidi shell mound cores). Consequently, benthic impacts associated with PA2 (WQ-6) are potentially significant and not mitigable (Class I).

MITIGATION MEASURES FOR IMPACT WQ-6

Significant impacts to sediment quality associated with PA2 are not mitigable because there is no feasible mitigation that would remove contaminants from the materials and reduce the potential for toxicity and contaminant bioaccumulation prior to spreading.

RESIDUAL IMPACT(S)

The residual impact for WQ-6 is significant (Class I).

Impacts: Changes in Bottom Sediment Characteristics

PA2 also would result in changes to some of the characteristics of bottom sediments in the vicinity of the 4H shell mounds. As discussed in Section 3.2.2, studies of sediment quality (SAIC 2003; Appendix G) indicated some notable differences in grain size and chemical characteristics between the shell mound and those of adjacent bottom sediments. Consequently, spreading the shell mounds into a layer up to 1 foot (0.3 m) thick over an area of 330 by 990 ft (100 by 300 m) would alter sediment quality over a relatively larger area than the present mound footprints. Due to the abundance of similar habitat and biota throughout the region, this alteration is considered a Class III impact. Shell mound materials eventually (within a minimum of one to three years) would be mixed by biological and/or physical processes and become indistinguishable from existing sediments.

Impacts: Caisson Removal

Impacts to marine water and sediment quality associated with the removal of caissons at the Hazel shell mound site for PA2 would be comparable to those associated with PA1. These impacts would consist of localized and temporary resuspension of bottom sediments and residual shell mound materials, with associated increases in near-bottom suspended sediment concentrations and turbidity levels at the Hazel site only. Some of these disturbed sediments may contain elevated contaminant concentrations. Bottom sediments disturbed by caisson removal activities would settle rapidly to the bottom. However, the amount of sediment disturbed by these operations, and the potential for impacts to water or sediment quality, would be small, temporary, and generally restricted to near-bottom waters in the immediate vicinity of the site. Based on the results of sediment testing (AMEC 2002), short-term exposures to the suspended particles would not cause significant toxicity to marine organisms. Therefore, this impact would be less than significant (Class III), and no mitigation is proposed.

SUMMARY

Potential impacts to water quality associated with spreading the shell mounds and removing the caissons at the Hazel site are expected to be short-term and localized, whereas potential impacts to sediment quality for longer-term sublethal effects and contaminant bioaccumulation would persist until the shell mound materials were mixed and diluted with the native bottom sediments. Following spreading of the mounds, there would be no potentials for future impacts associated with mound disturbances. None of the operations associated with PA2 would alter circulation to an extent that would result in persistent adverse effects on water quality or biological resources. Potential impacts described for PA2 would apply equally to each of the 4H shell mounds, except that minor impacts associated with caisson removal would apply only to the Hazel shell mound site.

3.2.4.3 Program Alternative 3 (PA3): Capping

PA3 would place a cap of clean sediments over one or more of the shell mounds. Capping would cover a mound with large quantities of clean sediments of a suitable texture (i.e., grain size). Placement of cap sediments around the base on the mound would also be required to reduce the slopes of the mounds sufficiently to make the area trawlable. Capping the shell mounds would require them to be designated by the USEPA as ocean disposal sites under the MPRSA.

Impacts

The objective of capping is to maintain the integrity of the shell mounds, with the goal to render their surfaces trawlable (see Section 2.4). Results from the caged mussel bioassay study (SAIC 2003) demonstrated that contaminants presently are not leaching from the shell mounds. Therefore, capping the mounds would not provide any beneficial impacts to existing marine water and sediment quality conditions. However, the presence of a cap layer would provide some protection from future disturbances of the mounds by trawling or other causes. The extent of this protection would depend on the thickness of the cap layer and the specific source and magnitude of the disturbance. If the cap is designed and constructed to encourage trawling, then the present risks of physically disturbing the mounds and exposing contaminated sediments would increase unless the cap material is renewed at a rate that is equal to or greater than the rate cap materials are eroded by trawl gear.

Placement activities would result in turbidity/suspended sediment plumes associated with each placement event. Unless the grain size of the capping materials matched those of the shell mounds and adjacent areas, some modifications to sediment texture would occur. The magnitude of this impact would reflect the similarities between the capping materials and native sediments at the shell mound sites. The source of sediments for capping would need to be an approved dredging project within the region, so that capping would not have additional impacts that would otherwise be associated with the excavation of a borrow site to obtain sediments for capping.

Potentially adverse impacts to water and sediment quality due to capping the shell mounds could occur, and these impacts are expected to consist of the following:

- Elevated suspended solids and turbidity levels during cap placement;
- Potential physical disturbances of the mounds during cap placement, resulting in releases of soluble contaminants and free product (petroleum) to waters above the shell mounds;
- Acute toxicity and contaminant bioaccumulation in aquatic organisms exposed to shell mound materials should they be dispersed during capping;
- Releases of soluble chemical contaminants associated with sediment pore waters (i.e., interstitial waters) squeezed from the shell mound sediments due to compaction caused by the added weight of the cap; and
- Changes in sediment characteristics in areas within the footprints of the caps.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA3	**WQ-7**	Rapid or uncontrolled placement of capping material could disturb the mound, releasing contaminated shell mound sediments with potential for toxic effects on marine biota.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

Impacts to marine water quality could result from disturbances to contaminated shell mound sediments if capping material is deposited in an uncontrolled manner that compromises the integrity of the mounds. Releases of shell mound contaminants into the water column and onto the surrounding seafloor could result in significant effects to biota due to the potential toxicity of the material, similar to impacts described for PA1 and PA2. Impact WQ-7 is considered significant but mitigable through careful placement of the cap layer and replacement of capping material as needed (Class II).

MITIGATION MEASURES FOR IMPACT WQ-7

WQ-7a *To reduce the chances of physical disturbances to the shell mounds, the Applicant shall use a down-pipe to deposit the cap material at low velocities.*

RESIDUAL IMPACT(S)

Following implementation of MM WQ-7, residual impacts to marine water and sediment quality from *PA3* would be less than significant. Assuming that a cap can be placed without disturbing the shell mound sediments, the effects of increased turbidity within the area during cap construction are considered short term, localized, and less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA3	**WQ-8**	The weight of the cap may further compact the mounds, causing the release of sediment pore waters and associated chemical contaminants to overlying waters.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

Impacts to marine water quality could result if the weight of the cap material causes further compaction and consolidation of the mounds, resulting in squeezing sediment

pore waters (i.e., waters associated with the spaces between individual sediment particles) from the mounds into overlying waters. Because pore waters likely contain contaminants, such as dissolved phase aromatic hydrocarbons, this process would result in some losses of contaminants from the mounds to near-bottom waters. The overlying cap layer will absorb a portion of the total volume of water expelled from the mounds. Other pore waters that are not absorbed by the cap layer will be mixed with near-bottom waters and rapidly diluted. This process would occur soon after the cap is constructed, but the rate of pore water release from the mounds would decrease rapidly as the rate of mound consolidation declines. Releases of shell mound contaminants into the water column would result in potentials for significant but short-term impacts to biota due to the potential acute toxicity of the dissolved contaminants. Impact WQ-8 is considered significant but mitigable by designing a cap that is thick enough to absorb the volume of pore waters expelled from the shell mounds (Class II).

MITIGATION MEASURES FOR IMPACT WQ-8

WQ-8a *Sixty (60) days prior to commencement of capping, the Applicant shall submit for approval by the California State Lands Commission and California Coastal Commission a final design the cap. The Applicant must demonstrate for the final cap design that the specified cap thickness is adequate to absorb the expected volume of sediment pore water potentially released from compacted shell mound materials. The minimum cap thickness shall not be less than 3.3 ft (1 m).*

RESIDUAL IMPACT(S)

Following implementation of mitigation measure MM WQ-8a, residual impacts to marine water quality would be less than significant. Assuming that a cap can be constructed as designed, the effects of consolidation during cap construction on releases of pore waters with chemical contaminants are considered short term, localized, and less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA3	**WQ-9**	Continuing risk of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

The cap would be designed to maintain the integrity of the shell mounds. Nevertheless, erosion or loss of the cap could be caused by bottom trawling, anchoring, biological activity, currents, or seismic events. These circumstances cannot be readily predicted or

addressed through design of the cap, and restrictions on trawling or other types of fishing would be inconsistent with the purpose of the cap. The loss of the cap itself would not have significant impacts, but it would increase the risk of deeper erosion that could cause the release of contaminants. Impact WQ-9 is considered significant but mitigable through regular assessments of the condition of the cap layer and replacement of capping material as needed (Class II).

MITIGATION MEASURES FOR IMPACT WQ-9

WQ-9a *The Applicant shall maintain a minimum cap thickness of 3.3 ft (1 m) at each shell mound site. The applicant shall conduct annual surveys of the capped areas to determine if and where the cap has eroded. The Applicant will use side scan, multibeam, or other appropriate and high precision methods approved by the California State Lands Commission and California Coastal Commission to determine volumes of the capped mounds. Changes in the estimated mound volumes of more than 10 percent from the post-capping volumes would be considered evidence for significant erosion. Capped areas that are less than 3.3 ft (1 m) thick, will be identified in Notices to Mariners and posted off-limits to trawling. The Applicant shall replenish exposed areas of the cap within 6 months of the survey.*

RESIDUAL IMPACT(S)

Following implementation of mitigation measure MM WQ-9a, residual impacts to marine water and sediment quality from PA3 would be less than significant (Class III).

Placement of a cap over a shell mound also will alter the characteristics of the seafloor within the footprints of the caps. Although details on the grain size of the capping material are not known, it is likely that it would be sandier than the surrounding natural sediments, thus resulting in the initial development of an infaunal community that would be somewhat different than that found on the existing natural seafloor (see Section 3.3). This is considered a Class III impact because subsequent deposition of natural sediments onto the cap material is expected to result in the eventual development of a biological community that is more similar to that occurring on and in the existing natural seafloor.

3.2.4.4 Program Alternative 4 (PA4): Artificial Reefs at all Four Shell Mounds

PA4 would leave the 4H shell mounds in place, but it would also add permanent structures (rock reefs) to the base of the mounds to improve the habitat value and provide protection against physical disturbances on the mounds.

Impacts

Development of the shell mounds into artificial reefs would not substantially alter existing water or sediment quality conditions, assuming that reef construction would not appreciably disturb the present mound structures and contaminants associated with the inner portions of the mound would not be released or remobilized to the environment.

Careful placement of ballast rock around the base of the mounds would cause only minor, localized, and short-term resuspension of bottom sediments and mound materials. Also, it would permanently alter sediment texture (i.e., from soft to hard bottom) over the relatively small footprint of the rock base. The presence of the rock base could minimize the long-term potential of disrupting the shell mounds by natural (storm-induced) or human (trawling, anchoring, etc.) processes.

However, potentially adverse impacts to water and sediment quality could occur if a substantial number of the reef rocks were inadvertently dropped on one or more of the mounds. Under these circumstances, impacts are expected to consist of the following:

- Elevated suspended solids and turbidity levels following release of the rocks.
- Potential physical disturbances of the mounds, resulting in releases of soluble contaminants and free product (petroleum) to waters above the shell mounds.
- Acute toxicity and contaminant bioaccumulation in aquatic organisms exposed to shell mound materials should they be dispersed during capping.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA4	**WQ-10**	Rapid or uncontrolled release of reef rocks could disturb the mound, releasing contaminated shell mound sediments with potential for toxic effects on marine biota.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

Impacts to marine water quality could result from disturbances to contaminated shell mound sediments if reef rocks are released in an uncontrolled manner that compromised the integrity of the mound. Releases of shell mound contaminants into the water column and onto the surrounding seafloor could result in significant effects to biota due to the potential toxicity of the material, similar to impacts described for PA1 and PA2. Impact WQ-10 is considered significant but mitigable through careful placement of reef rock around the mound perimeter (Class II).

MITIGATION MEASURES FOR IMPACT WQ-10

WQ-10a *To reduce the chances of physical disturbances to the shell mound sediments, the Applicant shall prepare and submit for approval by the California State Lands Commission and California Coastal Commission a detailed plan for constructing the reef. The plan shall include information on construction equipment and appropriate procedures for ensuring accurate placement of reef rocks and minimizing potentials for inadvertent releases of construction materials on top of the mounds.*

WQ-10b *Within 60 days following completion of reef construction, the Applicant shall conduct detailed surveys of the mounds using video cameras mounted on a remotely operated vehicle equipped with appropriate precision navigation systems. Within 120 days, the Applicant shall submit a report to the California State Lands Commission and California Coastal Commission containing the results from the surveys to document that construction activities have not compromised the integrity of the mounds.*

RESIDUAL IMPACT(S)

Following implementation of mitigation measures MMs WQ-10a and WQ-10b, residual impacts to marine water and sediment quality from PA4 would be less than significant. Assuming that a perimeter reef can be constructed without disturbing the shell mound sediments, the residual effects of increased turbidity within the area during reef construction are considered short term, localized, and less than significant (Class III).

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA4	**WQ-11**	Continuing risk of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

Although PA4 would provide some protection from future disturbances to the shell mounds, and therefore offer a net beneficial impact on water and sediment quality, this action would not remove the mounds. Future physical disturbances of unprotected portions of the mounds, caused by bottom trawling, anchoring, biological activity, currents, or seismic events, could cause or promote deeper erosion of the mound(s) that could release contaminants. Such disturbances are difficult to predict, but are reasonably likely to occur and incrementally degrade the shell mounds over the long term. Impact WQ-11 is considered significant but mitigable (Class II) through regular assessments of the condition of the mounds.

MITIGATION MEASURE FOR IMPACT WQ-11

WQ-11a *The Applicant shall survey conditions at the 4H shell mounds every 6 months to document that conditions have not changed. The Applicant shall use side scan, multibeam, or other appropriate and high precision methods to determine the volumes of each of the remaining shell mounds. If estimates of the volumes agree within 10 percent of the previous estimates, then the conditions of the mounds can be considered unchanged. If disturbances of the mounds are observed, and/or the volume estimates are more than 10*

> *percent lower than previous estimates, the Applicant shall either remove (e.g., PA1) or remediate (e.g., partial or complete capping [PA3]) the contaminated sediments. If the mounds are left in place, the Applicant shall document that no significant toxicity or bioaccumulation is occurring. The Applicant shall submit for approval by the California State Lands Commission and California Coastal Commission, and in consultation with the Central Coast Regional Water Quality Control Board, a plan that describes the approach for the above. If after 10 years, no detectable changes in the condition of shell mounds are detected, the resource agencies can review the findings and in consultation with the Applicant modify the requirements as appropriate.*

RESIDUAL IMPACT(S)

Following implementation of mitigation measure MM WQ-11a, residual impacts to marine water and sediment quality from PA4 would be less than significant (Class III).

3.2.4.5 Program Alternative 5 (PA5): Artificial Reef at Hazel after Removing (5a) or Spreading (5b) Shell Mounds

Unlike PA4, which would construct a perimeter reef around each shell mound, under PA5, an artificial reef would be constructed at the Hazel site only, using the caissons as the cornerstones of an artificial reef. Quarry rock of the same dimensions as used for PA4 would be used to fill in the structure of the reef between and around the caissons, resulting in an artificial reef of about one acre. As with PA4, the structure of the reef could be augmented with other materials. The placement of a single relatively large reef at the Hazel site contrasts with the four relatively small reefs that would ring the shell mounds under PA4. There are two variants to this alternative, depending on whether the shell mound materials are a) removed as under PA1, or b) spread as under PA2. Each is discussed separately below.

Program Alternative 5a (PA5a): Artificial Reef at Hazel Site plus Removal and Disposal of Shell Mounds

This alternative would employ the same procedures and have the same impacts (WQ-1 through WQ-4), with corresponding mitigation measures (MM WQ-2(all), WQ-3a, MB-4a and 4b), as PA1. Construction of an artificial reef at the Hazel site would not provide any additional beneficial impacts to marine water quality or sediment quality or reduce the magnitude of residual impacts associated with mound removal operations.

Program Alternative 5b (PA5b): Artificial Reef at Hazel Site plus Leveling and Spreading Shell Mounds

This alternative would employ the same procedures and have the same impacts (WQ-5 and WQ-6), and corresponding mitigation measures (MM WQ-5a), as PA2. Construction of an artificial reef at the Hazel site would not provide beneficial impacts to marine water quality or sediment quality or reduce the magnitude of residual impacts associated with mound spreading and smoothing operations.

3.2.4.6 Program Alternative 6 (PA6): Offsite Mitigation

This alternative would not remove or alter the 4H shell mounds. Several off-site fisheries enhancement measures could be included, but these are more applicable to commercial and recreational fishing, which is discussed in Section 3.5.

Impacts

The results of the sediment testing (AMEC 2002) demonstrate that the 4H shell mounds contain elevated concentrations of a number of chemicals that can cause significant acute toxicity and contaminant bioaccumulation in aquatic organisms. Contaminants responsible for acute toxicity appear to be distributed mostly in the interior portions of the mounds. At the same time, the presence of significant quantities of volatile aromatic hydrocarbons in the mound sediments indicates that the mounds are relatively resistant to disturbance by natural processes, as well as operations associated with platform abandonment, fishing, and scientific studies that have occurred since the platforms were removed. As such, shell mound contaminants presently do not appear to be significantly degrading water quality or sediment quality in areas adjacent to the mounds. This conclusion is consistent with the absence of significant differences in contaminant bioaccumulation at the shell mound sites observed by the caged mussel bioassay study (SAIC 2003). The Offsite Mitigation Program Alternative (PA6) would not intentionally release these contaminants to the environment or expose aquatic organisms to toxic or bioaccumulative substances. However, because the 4H shell mounds would not be removed or otherwise protected from potential future disturbances, PA6 represents a continuing risk of contaminant release. Future disturbance of the mounds and related impacts to water and sediment quality by human activities or natural processes is difficult to predict, but is reasonably likely to occur and incrementally degrade the shell mounds over the long term. The risks under PA6 are relatively higher than those associated with enhancement alternatives (e.g., as artificial reefs) in which mounds are potentially protected from physical disruption.

For the Offsite Mitigation Program Alternative, potentially adverse impacts to water and sediment quality could occur following substantial disturbances to the mound, and these impacts could consist of the following:

- Releases of soluble contaminants, especially lower molecular weight aromatic hydrocarbons and free product (petroleum), to waters above the shell mounds.
- Formation of an oil sheen on the water surface from release/spills of petroleum hydrocarbons associated with disturbed shell mound materials.
- Acute toxicity and contaminant bioaccumulation in aquatic organisms exposed to disturbed mound materials.

Program Alternative	*Impact #*	*Impact Description*	*Region/Location*	*Class*
PA4	**WQ-12**	Continuing risks of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	Offshore Santa Barbara County. The impact could affect water quality within several hundred feet of the shell mound sites.	II

Impacts

Although the 4H shell mounds presently do not appear to cause significant impacts to marine water or sediment quality, the potential for future disturbances of the mounds, with possibilities for significant remobilization of contaminants to the environment, cannot be eliminated. Contaminant releases from the shell mounds could occur in the future in response to substantial degradation of the physical integrity of the mounds due to structural changes (e.g., sloughing or dissolution of the outer shell layer) or mechanical disturbance (e.g., scraping by trawl nets or anchor scars). The existing bulk chemical composition of the shell mound materials suggests that the mounds have not been actively disturbed over a period of several decades. Thus, the future probability that all four mounds would be substantially compromised appears to be small. Regardless, physical disturbances that expose portions of the mounds containing chemical contaminants could result in toxicity and/or contaminant bioaccumulation in exposed aquatic organisms, which is considered a potentially significant impact.

The magnitude of potential toxic or contaminant bioaccumulation effects would be related to the extent of any mound disturbances and the mass of contaminants released or exposed. As a worst case, if all mounds were disturbed, the magnitude of toxicity and contaminant bioaccumulation could be comparable to that of the PA2 spreading action. If only portions of one or more mounds were disturbed, the magnitude of impacts could be comparable to those associated with other removal (i.e., PA1 or PA5a) or modification alternatives (e.g., PA3 or PA4). A fundamental difference between the Offsite Mitigation Program Alternative (as well as PA3 and PA4) and the removal actions is that potential risks for future contaminant releases to the environment persist. Regardless, impacts associated with exposures of aquatic organisms to potentially toxic or bioaccumlative substances would be localized to the immediate area of the disturbed mound(s). Impact WQ-12 is considered potentially significant but mitigable to less than significant (Class II), as described for PA4.

MM WQ-11a would also apply to this impact.

RESIDUAL IMPACT(S)

Following implementation of mitigation measure MM WQ-11a, residual impacts to marine water and sediment quality from the Offsite Mitigation Program Alternative would be less than significant (Class III).

3.2.4.7 No Project Alternative

Under the No Project Alternative, the shell mounds would be left in place and no on- or offsite mitigation measures would be implemented. As such, there would be a continuation of the following impact as discussed in previous sections:

1. Ongoing risk of contaminant releases from the shell mounds if the mounds are damaged.

Table 3.2-8. Summary Matrix of Potential Impacts to Marine Water and Sediment Quality Associated with Program Alternatives

Program Alternative	*Impact #*	*Potential Impact*	*Impact Class*	*Mitigation Measures*
PA1	WQ-1	Permanent removal of contaminated sediments.	IV	*None proposed*
	WQ-2	Disturbance and resuspension of shell mound materials from dredging-related operations.	II / III	*MM WQ-2a. Use of enclosed (environmental) bucket dredge and approved dredging practices, including conducting operations during favorable wind and sea conditions.* *MM WQ-2b. Submittal of design and operating procedures for a filtration system for dewatering barge, and subsequent installation on dewatering barge.* *MM WQ-2c. Plan for implementing additional Best Management Practices (BMPs) to reduce suspended sediment levels* *MM WQ-2d. If the Waste Discharge Requirement (WDR) for the decant water discharge specifies the spatial limit of the initial mixing zone, the Applicant shall document that the quality of the discharge meets specific limits for water quality parameters at the boundary of or beyond the mixing zone.* *MM WQ-2e. Provision of on-site response team with equipment.*
	WQ-3	Residual contamination associated with mound materials that are not removed by dredging and smoothing.	II / III	*MM WQ-3a. Conduct post-clearance surveys.*

Table 3.2-8. Summary Matrix of Potential Impacts to Marine Water and Sediment Quality Associated with Program Alternatives (continued)

Program Alternative	*Impact #*	*Potential Impact*	*Impact Class*	*Mitigation Measures*
	WQ-4	Toxicity/bioaccumulation resulting from: • disposal of dredged materials offshore; or	I	*None feasible.*
		• spills of dredged materials during transport to/unloading at onshore transfer point.	II	*MMs WQ-2a (approved practices including limits on loading barges), MB-4a and MB-4b would apply.*
PA2	WQ-5	Disturbance and resuspension of shell mound materials from leveling/spreading-related operations.	II / III	*MM WQ-5a. Provision of on-site response team with equipment.*
	WQ-6	Chronic toxicity and contaminant bioaccumulation in areas where spreading and mixing with native sediments are inadequate to reduce contaminant concentrations to the extent they are no longer deleterious.	I	*None proposed.*
PA3	WQ-7	Rapid or uncontrolled placement of capping material could disturb the mound, releasing contaminated shell mound sediments with potential for toxic effects on marine biota.	II	*MM WQ-7a. Use a down pipe to deposit cap material carefully and at low velocities over the shell mounds.*
	WQ-8	The weight of the cap may compact the mounds, causing releases of sediment pore waters and associated chemical contaminants to overlying waters.	II	*MM WQ-8a. Design and specify a cap thickness that is sufficient to absorb the volume of pore water potentially released from the mounds.*
	WQ-9	Continuing risk of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	II	*MM WQ-9a. Conduct annual surveys to document that the cap thickness remains 3.3 ft (1 m) or greater, and replenish areas of the cap as needed.*

Table 3.2-8. Summary Matrix of Potential Impacts to Marine Water and Sediment Quality Associated with Program Alternatives (continued)

Program Alternative	*Impact #*	*Potential Impact*	*Impact Class*	*Mitigation Measures*
PA4	WQ-10	Rapid or uncontrolled release of reef rocks could disturb the mound, releasing contaminated shell mound sediments with potential for toxic effects on marine biota.	II	*MM WQ-10a. Prepare a detailed plan for constructing the reef that addresses construction equipment and appropriate procedures for ensuring accurate placement of reef rocks and minimizing potentials for inadvertent releases of construction materials on top of the mounds.* *MM WQ-10b. Conduct post-construction surveys.*
	WQ-11	Continuing risk of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	II	*MM WQ-11a. Conduct annual surveys to document that the volumes of the mounds have not changed. If the mound volumes have changed, remove or remediate the mounds..*
PA5a/b	WQ-1 through WQ-4 for PA5a; WQ-5 and WQ-6 for PA5b	Same as for PA1 and PA2	I-IV	*MM WQ-2 (all), WQ-3a, MB-4a and -4b for PA5a; MM WQ-5a for PA5b.*
PA6	WQ-12	Continuing risks of contaminant releases to the environment, with potential toxicity and bioaccumulation effects to aquatic organisms.	II	*MM WQ-11a would apply.*